POWER PLANT ENGINEERING

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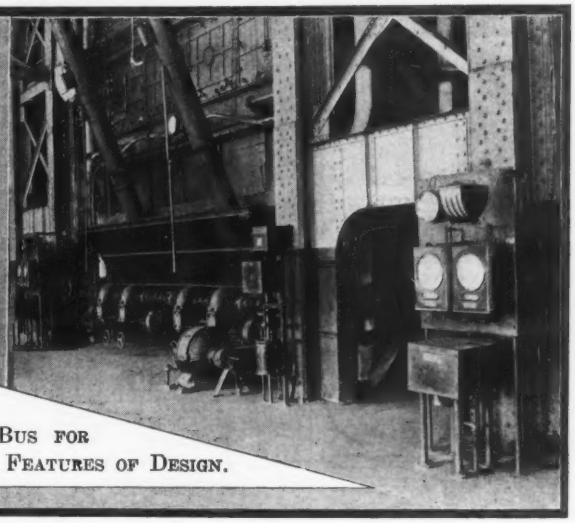
Barbadoes Island Plant Illustrates Modern Central Station Design



ELECTRIFIED AUXILIARIES, DOUBLE EFFECT EVAPORATORS, MOTOR OPERATED VALVES, STARTING BUS FOR MOTORS, AND LOOP SYSTEM OF BOILER FEED ARE FEATURES OF DESIGN.

BETWEEN the towns of Bridgeport and Norristown, Pa., is an island in the Schuylkill River known as Barbadoes Island. On this island the U. G. I. Contracting Co., of Philadelphia, is just completing a power station with an initial rating of 40,000 kw. for the Counties Gas & Electric Co., which illustrates some of the modern tendencies in central station design. Electrified auxiliaries, no house turbine, double effect evaporators, motor operated valves, 1100-v. starting bus for auxiliary motors, loop system of boiler feed, 300 lb. boiler pressure, and tile construction for the building are a few of the points of interest which are indicative of present day practice.

Since the Norristown plant of the Counties Gas & Electric Co. is located just across the river from the Barbadoes Island station it was not considered necessary to have a house turbine. It was felt that the two sources of energy supply for the auxiliaries; that from the house service buses and the lines from the Norristown station, would adequately protect the Barbadoes plant against any emergency which might arise in the way of service interruptions. The heat balance of the plant was therefore laid out without the inclusion of exhaust from a house turbine system. Steam for the evaporators is taken at boiler pressure and reduced to 175 lb. and the steam for heating feed water is obtained by bleeding the main units and from such auxiliaries as safety has indicated should be steam driven. Should it be desired at any time a house turbine can be added without materially changing the mode of operation as far as the general heat balance is concerned. It is quite possible that when the station reaches its ultimate capacity of 120,000 kw. the Norristown plant will not be operated, in which case the house turbine arrangement may be adopted.

Two 20,000-kw. Westinghouse turbo-generators comprise the present prime mover equipment. The first of these machines was of the semi double-flow type and the second one which is now going in, is the new Bauman single flow design. These units are supplied with 250 lb. steam at the throttle by three 1680-hp. Springfield boilers.

In all of the details of design such as coal handling, ash disposal, and the water supply system careful attention has been given to points which have a bearing on efficient operation, safety and access for repairs. Ample space has been provided in all galleries and the station is well lighted from the standpoint of both natural and artificial illumination.

At one end of the island the main line of the Philadelphia & Reading Railroad crosses the Schuylkill River and a spur from this road has been built to give the plant rail service. Coal is therefore brought in by rail in hopper bottomed cars and is weighed on a Standard Scale and Supply Co. 150-T., 50-ft. rigid-deck type track scale. It is possible to dump the coal into the track hopper or it may be unloaded onto the storage pile by the use of two stiff-legged derricks and a locomotive crane. These derricks are used in reclaiming from storage, this operation requiring that the coal be loaded in cars and then dumped into the track hopper. Some 40,000 T. may be stored in the area covered by the stiff legged derricks and crane.

Reciprocating feeders feed the coal into two two-roll crushers. The crusher rolls are of the rimmed tooth

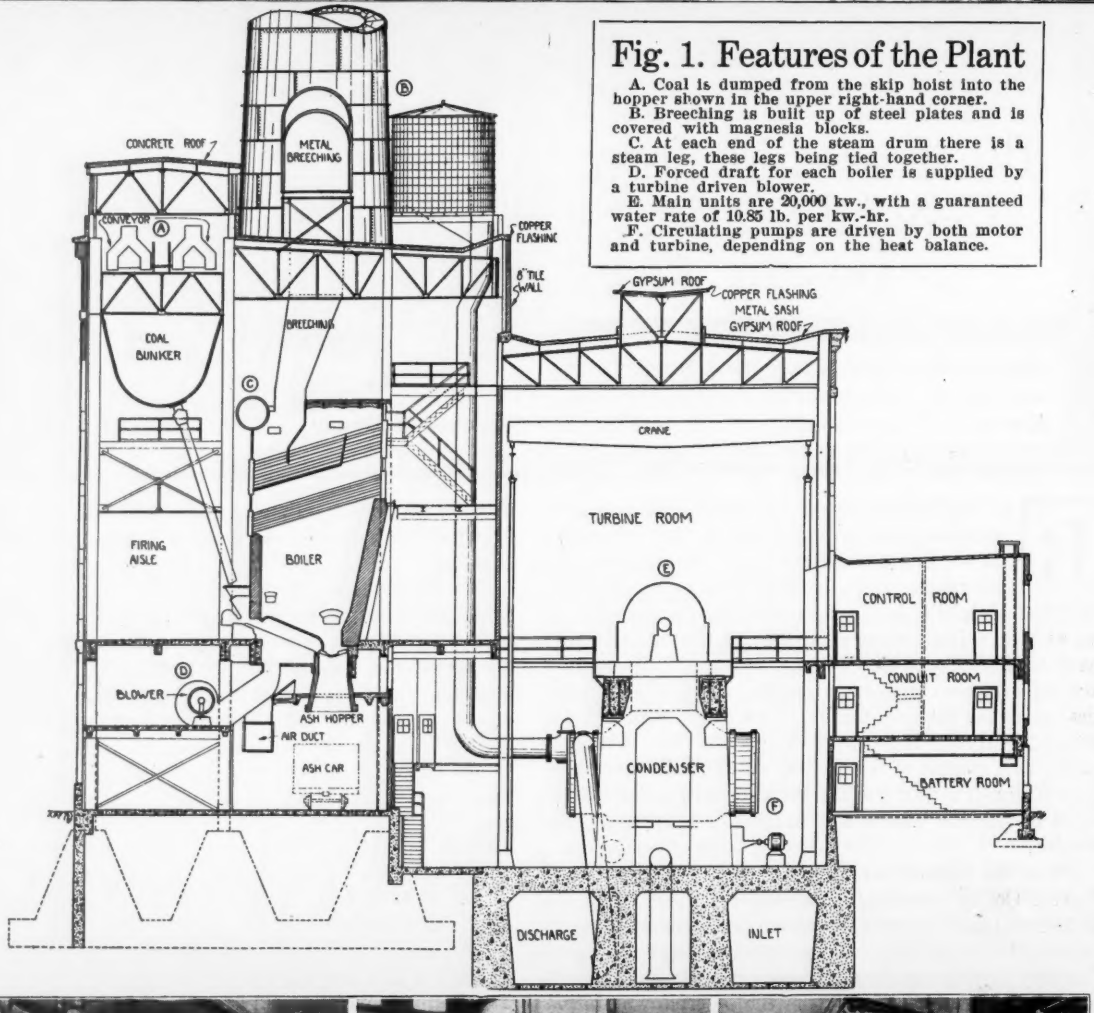


Fig. 1. Features of the Plant

A. Coal is dumped from the skip hoist into the hopper shown in the upper right-hand corner.

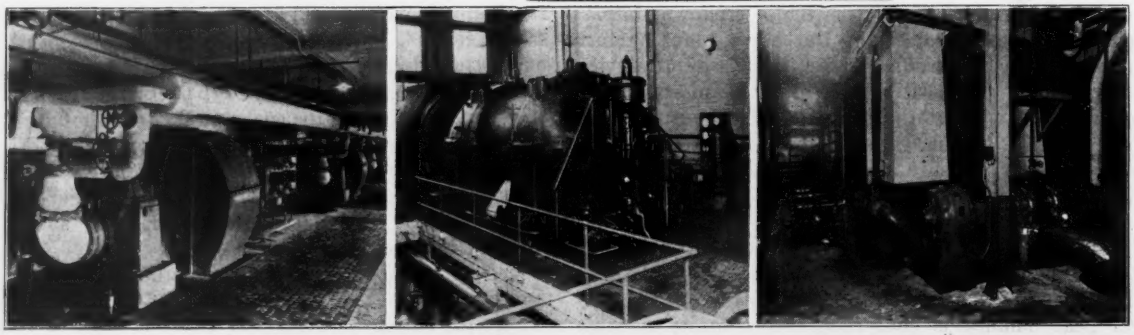
B. Breeching is built up of steel plates and is covered with magnesia blocks.

C. At each end of the steam drum there is a steam leg, these legs being tied together.

D. Forced draft for each boiler is supplied by a turbine driven blower.

E. Main units are 20,000 kw., with a guaranteed water rate of 10.85 lb. per kw.-hr.

F. Circulating pumps are driven by both motor and turbine, depending on the heat balance.



type, 28 in. diameter by 30 in. long. One roll of each crusher is mounted in rigid bearings and the other in spring-relief bearings. The crushers are driven by 15-hp., 220-v., wound rotor motors which are connected to the crusher counter shaft by cast iron spur gears and steel pinions on the motors. The crushing equipment has a rated capacity of 100 T. per hr.

Balanced Type Skip Hoist Handles Coal

Crushed coal is received in hoppers and is automatically loaded into two skip buckets by Simplex loaders. The R. H. Beaumont Co. skip hoist is of the balanced type, one bucket loading while the other discharges. The crushed coal is discharged by an automatic tripper from the skip buckets into a receiving hopper located at the top of the tower. From the receiving hopper the coal is loaded on the conveyor belt by a Robbins feeder and is discharged into the bunkers by an automatic tripper.

That part of the coal handling equipment located above the bunkers was furnished by the Robbins Conveying Belt Co. The belt is a Goodrich, 5-ply, 24 in. wide and runs the full length of the bunkers. It is

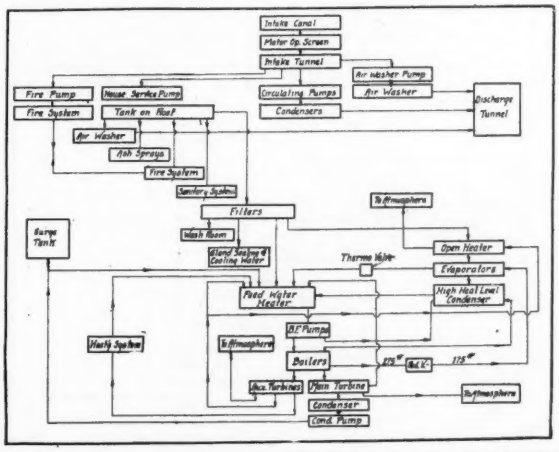


FIG. 2. WATER FLOW IS AN IMPORTANT PART OF MODERN STATION DESIGN

driven by a 7½-hp. motor. The tripper as shown in Fig. 1 elevates the belt and discharges the coal through a chute. It is possible to set this tripper at one location or by throwing on the drive it will move slowly back and forth over a selected length of the bunkers discharging the coal as it goes. In this way it is possible to distribute the coal as desired.

A suspension type steel bunker is used which is 115 ft. long, 18 ft. 6 in. wide at the top and 20 ft. deep. Curved partitions divide the bunker into three sections or one hopper for each boiler. These partitions have the same curvature as the sides of the bunker and were found to be necessary in order to eliminate the dead pockets of coal which might give trouble due to spontaneous combustion.

One feature of interest in connection with the coal handling layout is the electrical interlock in the various steps. It is not possible, for instance, to start up the crushers until the conveyor belt and the skip hoist are running.

Coal is drawn from the bunkers through gates, operated from the firing floor, and fed to the stokers through swinging steel chutes. There are two of these chutes, each equipped with Bailey coal meters, for each stoker hopper.

Boilers Are 1680 hp. Each

At present the boiler room is made up of three 1680-hp. Springfield boilers, although the ultimate capacity of the station will require 16 of these units. The

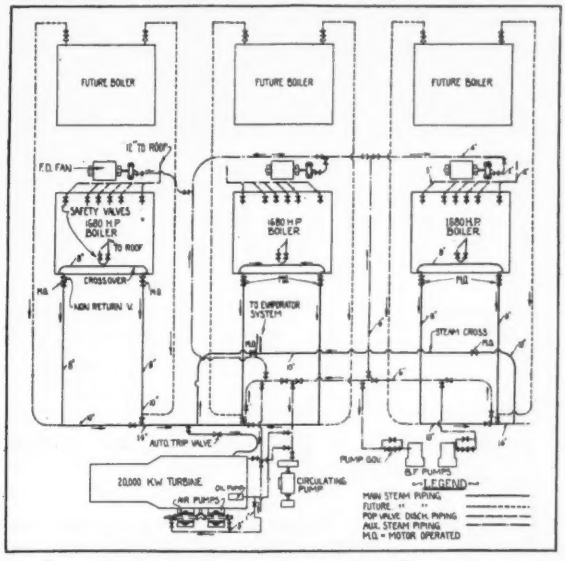


FIG. 3. STEAM PIPING IS SECTIONALIZED AND RAPID CONTROL IS PROVIDED BY MOTOR OPERATED VALVES

boilers are fired by Westinghouse underfeed stokers 12 retorts wide, with a projected grate area of 287.5 sq. ft. As the boiler heating surface is 16,800 sq. ft., the ratio of heating surface to grate area is 58.4. In accordance with present day practice, the furnace volume is relatively large, totaling 4970 cu. ft. or 0.295 cu. ft. per sq. ft. of water heating surface. The furnace setting is of the Murray type in a casing and the standard Springfield arrangement of baffles is used in the boiler.

These Springfield boilers are single drum three pass type, made up of 1056-2-in. tubes, 20 ft. in length. The steam drum is 60 in. in diameter with a shell thickness of 57/64 in. and a head thickness of 15/64 in.

Superheaters are arranged with a header on one side with the elements located between the first and second tube banks. These superheaters were furnished by the Superheater Co. and the heating surface is 1700 sq. ft. or about 10 per cent of the boiler heating surface. At 200 per cent, this amount of heating surface will give a superheat of 200 deg. F.

One interesting feature of the boiler room is in the method of securing combustion control. The furnace pressure is maintained constant by a Brooke controller which is so connected that it actuates the blast gate between the blower and the boiler and a Ruggles-Klingemann chronometer valve in the steam line to the turbine drive of the blowers. As the steam pressure changes, a Ruggles-Klingemann regulator changes the position of the stack damper. This change in the stack damper position changes the pressure over the fire and this variation in pressure operates a diaphragm balance in the Brooke control which is the electrical circuit to a small motor. This motor then operates the chronometer valve

in the steam line to the fan, bringing the wind box pressure to a proper value to restore the balance above the fire. At the same time, the control device also operates the stoker controller through a cable connection.

Ordinarily the stoker speed depends upon the stack damper movement, and if the fuel resistance does not change, the stoker speed will change directly only with

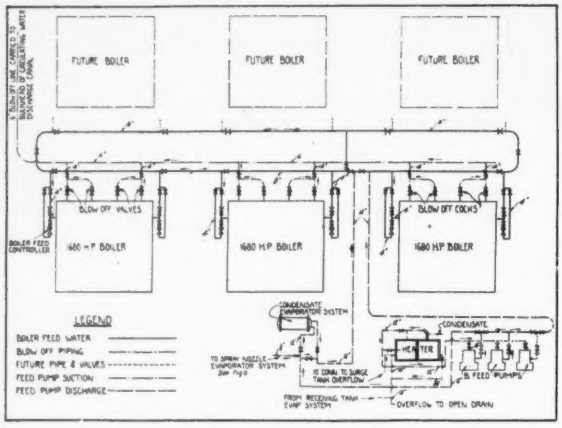


FIG. 4. LOOP SYSTEM OF FEED PIPING ASSURES AGAINST FAILURE OF BOILER FEED

the movements of this damper. If, however, the fuel bed becomes thin, or short, then the stoker is speeded up, and if thick, it is slowed down.

With this system of forced and natural draft the air pressure in the ash pit is maintained at 2 to 6 in., above the grate at about —.1 in., and in the last pass it is about —1.5 in.

Stack Is Supported on Building Steel

Natural draft is provided by a steel stack 300 ft. high above the grate, 24 ft. in diameter at the breeching and 18 ft. in diameter at the top. This stack is lined with a 4-in. brick lining which extends to the top. A special structural arrangement of building steel is used for supporting the stack. According to present plans there will be one of these stacks for each group of boilers, which will mean four stacks for the ultimate station rating of 120,000 kw.

Forced draft is supplied by three 65,000 cu. ft. per min. Sturtevant fans which are driven by Westinghouse turbines rated at 119 hp. at 1280 r.p.m. From the plant cross-section shown in Fig. 1, it will be noted that these fans are located on a gallery floor just below the firing room floor. Each fan has a direct connection to the furnace it supplies and there is also an interconnecting duct which is supported from the boiler room floor. These ducts are made up of sheet steel and were built by the Heilman Boiler Works of Allentown.

Since it is the expectation to use the ashes to build up Barbadoes Island above the high water level, the general scheme of ash handling is comparatively simple. Ashes are dumped into the Baker-Dunbar ash hoppers which are equipped with air operated ash gates and arranged for intermittent quenching. The hopper gates are 5 ft. 6 in. wide with a 6 ft. 6 in. stroke, cast-iron construction and lined with fire tile. These gates discharge the ash into standard gage industrial dump cars; but if it is desired, standard railway dump cars may be used since the headroom has been made sufficient to permit the operation of such equipment.

Cross-Over Between Steam Legs Protects Superheaters

In the arrangement of steam piping shown in Fig. 3, it will be noted that the two steam legs are tied together by an 8-in. cross-over. This cross-over is ahead of the Edwards non-return valves and the Nelson motor operated gate valves so that complete protection is afforded the superheaters.

If the valves in one of the steam legs should be shut off, steam would continue to flow through that particular superheater, through the cross-over and into the other steam leg. This eliminates the possibility of burning out a superheater. In addition, the cross-overs are protected by safety valves which are set to blow at a lower pressure than those on the drums. This also protects the superheaters, as it assures a continued flow of steam at times when a boiler may be cut off the line. In such a case, the safety valves on the cross-over would

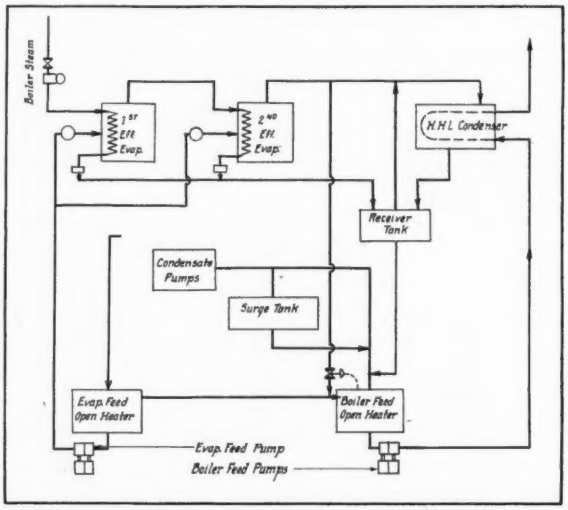


FIG. 5. EVAPORATION IS HANDLED BY THE DOUBLE EFFECT, HIGH-HEAT-LEVEL CONDENSER SYSTEM

blow and the flow of steam would tend to keep the superheater temperatures below the danger point.

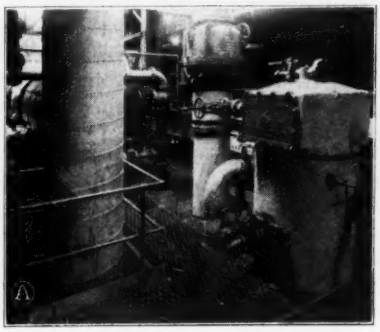
Steam lines have an insulation thickness of 4½ in., of which 3½ in. is 85 per cent magnesia, ½ in. plaster next to metal and ½ in. plaster as exterior protection for the magnesia. This insulation was installed by the American Insulation Co.

Garlock ring type packing is used in all of the high pressure steam joints.

Motor operated valves are also used in a number of places besides the ones on the steam legs. There are two of these valves in the 10-in. cross-over between the main steam headers, one in each 14-in. turbine lead and all of the valves in the 30 in. and 36 in. circulating lines are operated by motor drive.

Water System Laid Out to Supply 282,000 G.P.M.

As will be noted from Fig. 7, the water supply to the station is drawn through an intake channel which is protected at the entrance by log type sluice gates and at the end of the channel are located the Chain Belt Co.



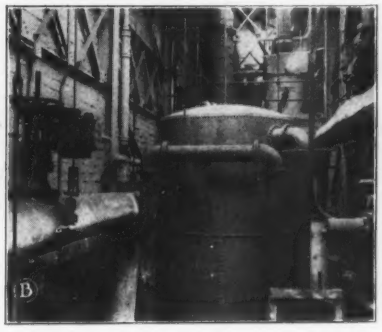
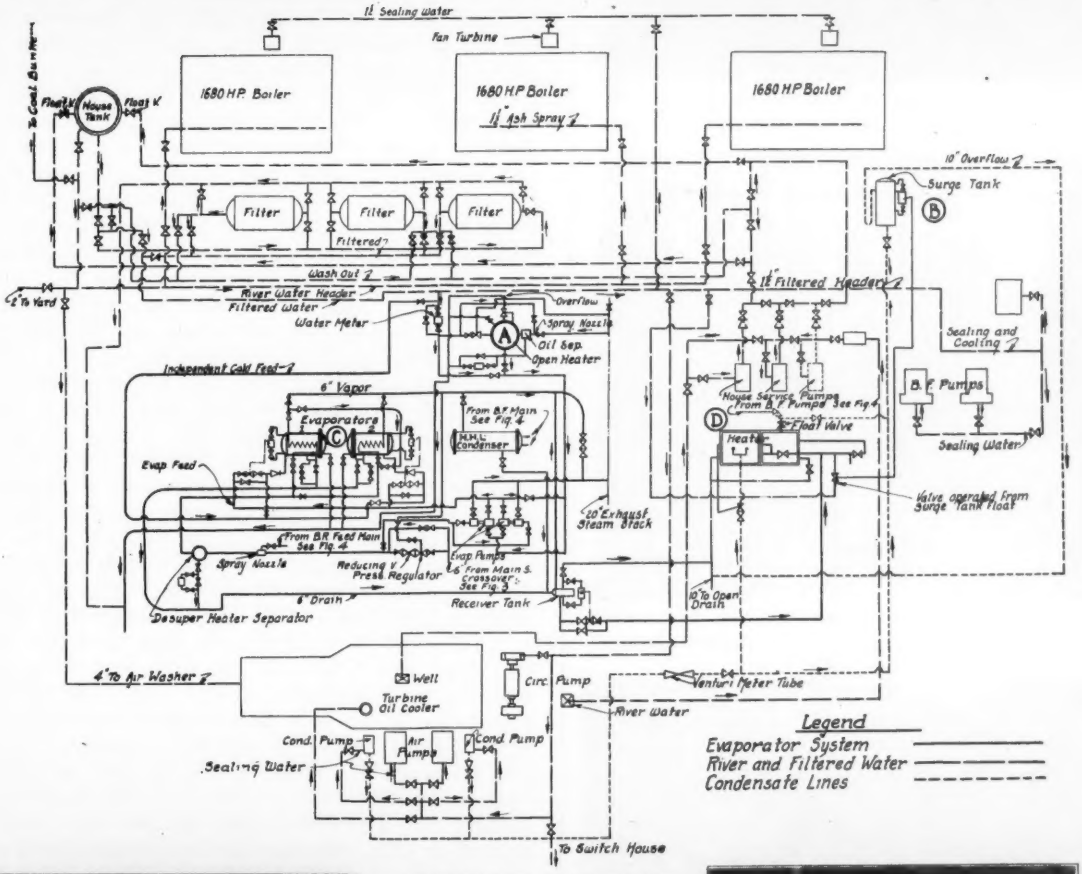
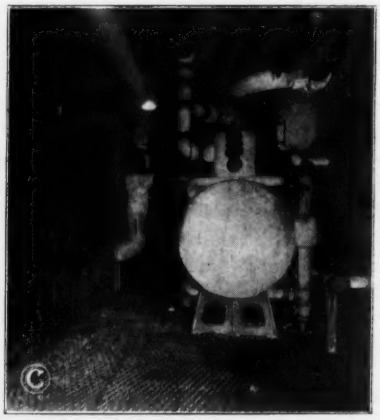


Fig. 6. Piping for the Water System

A. This view shows the filter floor. In the foreground is the evaporator feed water heater Just back of this heater is the 20 in. exhaust steam stack with multiport relief valve. At the left is the 36 in. exhaust line which protects the main units against a failure of the condenser system.

B. In the center of this view is shown the 5000 gal. steel surge tank which is used to store condensate in order to even the flow to the boiler feed heater when the load conditions are fluctuating.





C. Evaporator floor showing the 12,000 lb. per hr. double effect evaporators. The steam pipe coming out of the boiler is the lead from the superheater. At this point the 8 in. cross-over connection is made. This cross-over is the pipe which makes the right angle bend from above.

D. Feed water is heated in this 600,000 lb. per hr. capacity feed water heater. Water is metered with a V-notch and the recorder is located on the heater. At the right center may be seen the thermostatic element which controls the steam to the circulating pump turbine. In the lower right is the float operated valve which regulates the amount of condensate fed to the heater. There are a number of float valves in the system, as the surge tank and evaporator receiver tank are controlled in this way. If condensate in the surge tank falls below a certain level the heater is supplied with filter water.

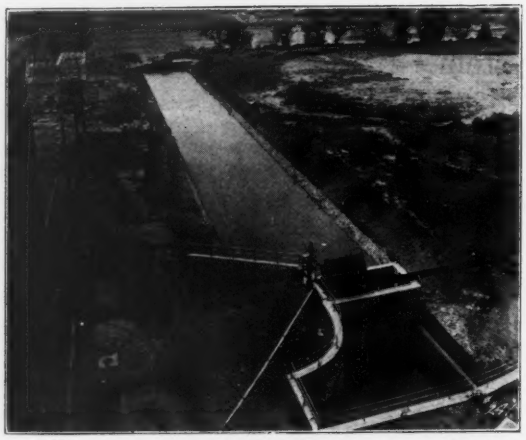


FIG. 7. WATER IS DRAWN THROUGH THE CHANNEL AND PASSES TO INTAKE THROUGH ROTATING SCREENS

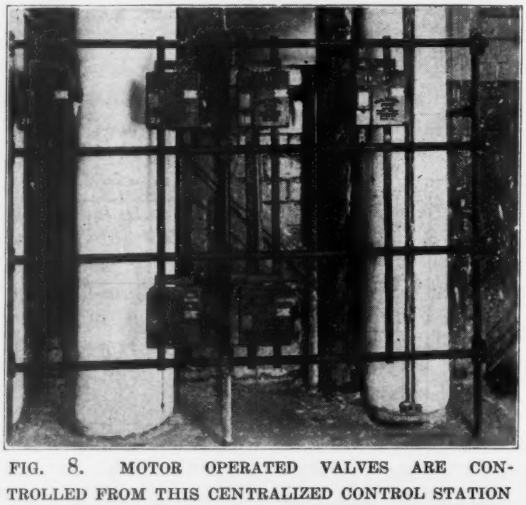


FIG. 8. MOTOR OPERATED VALVES ARE CONTROLLED FROM THIS CENTRALIZED CONTROL STATION

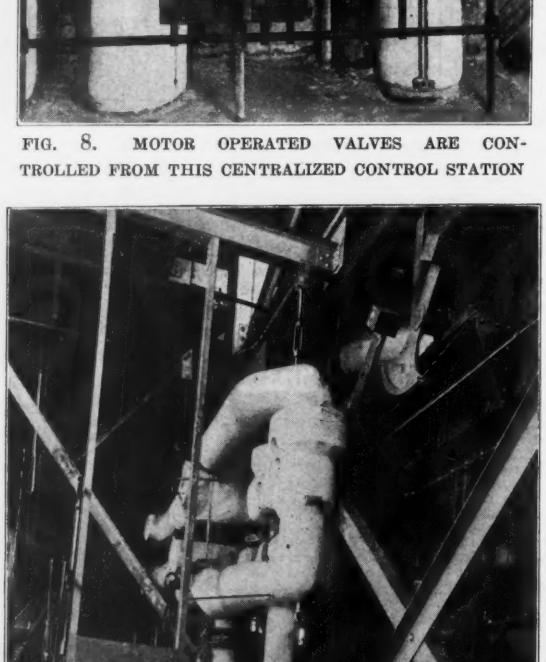


FIG. 9. FEED WATER CONTROLLER, DAMPER SHEAVES AND ONE OF THE SOOT BLOWERS ARE SHOWN HERE

revolving screens. This channel has been laid out to provide the 282,000 g.p.m. which will ultimately be required by the six 20,000-kw. units. This channel is 11 ft. 6 in. wide at the bottom, 12 ft. 6 in. wide at the water level and 13.5 ft. deep. These revolving screens have a vertical travel and are motor driven. The screen baskets are cleaned by a water spray.

Since the water supply problem is an important one in a station of this size, it is interesting to note how this water is distributed for the various requirements. In Fig. 2 is shown a simplified water flow diagram which takes the water from the time it enters the intake canal until it enters the discharge tunnel as well as that portion of the water which is recirculated through the evaporating and condensing cycle.

From the intake tunnel, most of the water is passed through the condensers by the circulating pumps and passes out through the discharge tunnel. Some of it is required for the air washer and the balance for the house service. The house service pump elevates the water to a tank on the roof of the station. From this tank a part of it passes through sand and gravel filters into the main feed water heater or the evaporator feed water heater as the case may be. From then on the water circulates either as water, steam or vapor as it passes through the station operating cycle.

Feed water piping is arranged in a loop system as shown in Fig. 4 so that any section may be isolated if desired. There are four feed lines to each boiler drum, one on each side with a Stets feed water regulator and one line on each side for hand feed. As previously mentioned, the make-up feed water is drawn from the sand and gravel filters by two 1000-gal. per min. Cameron centrifugal pumps and pumped to the 600,000-lb. per hr. capacity open type Cochrane metering heater.

Make-up feed water is distilled by double effect 12,000 lb. per hr. capacity Griscom-Russell evaporators. The simplified evaporator cycle is shown in Fig. 5, while the complete piping diagram is shown in Fig. 6.

In this system, steam is taken from the boiler, throttled down to 175 lb. and passed through a de-superheater in which the spray is boiler feed. First the steam passes through the first effect where it gives up its heat to the make-up water fed into the evaporator. During this operation, the steam condenses and the make-up water in the first effect is vaporized. The condensate is drained into a receiving tank and the vapor from the first effect passes through the coils of the second effect where it gives up its heat in distilling the make-up water fed to this unit. The condensed vapor also drains into the receiving tank while the second effect vapor passes to the high heat level condenser.

Boiler Feed Used as Circulating Water

Boiler feed at a temperature of 210 deg. F. passing on its way from the Cochrane heater is used as circulating water in the high-heat-level condenser. The condensate from this condenser is also drained into the receiver tank. In other words, distilled make-up is received from three sources: the condensed boiler steam which was used in the first effect, condensed vapor from the first effect and condensed vapor from the high-heat-level condenser.

From the receiving tank the distilled make-up passes by gravity to either the high heat level condenser or to the main feed heater, depending on the temperature

at which it leaves the receiving tank. A thermo operated valve determines this direction of flow. If the temperature of the make-up is less than the boiler feed leaving the Cochrane heater, the distillate is passed through this heater.

Since the main circulating pumps are also provided with a turbine drive, the exhaust from these units is available for feed heating if needed. The method of drive, that is whether it is to be by motor or turbine, is determined by the Ruggles-Klingemann system of thermo control on the Cochrane heater. If the heater temperature drops below a specified point, the control cuts in the turbine and the motor circuit is disconnected. If the motor drive should fail a solenoid operates to start up the turbine. In addition, the feed heating system is also supplied with steam from a bleed point on the main units.

Operating Conditions Checked by Instruments

Each boiler has its own instrument panel located on a column at the front right-hand side of unit as will be noted from the view of the boiler room shown in the headpiece of this article. Instruments which are located on this panel and on the building column itself are as follows: Republic CO_2 meter, Foxboro recording thermometer for feed water, Bailey multipointer gage, two Bailey steam flow meters, and a Precision Instrument Co. draft gage.

Readings of CO_2 are taken from the last pass of the boilers. The multipointer gage reads the windbox pressure, fire box draft and uptake draft all in inches of water and the stoker speed in seconds per revolution.

Steam flow in one leg and the totalized blow in both legs are recorded by the Bailey boiler meters. The totalizing meter is equipped for recording air flow and the scale is so adjusted that if the steam flow curve falls below the air flow line it indicates either that there is an excess of air or a deficiency of fuel. Deficiency of air or excess of fuel is shown when the steam flow curve is above that for air. In addition, Foxboro recording thermometers are used for flue gas, Foxboro indicating thermometers on the feed water lines and on the superheated steam legs.

At the base of the instrument panel is located the Brooke control apparatus. The Dean control boxes for the motor operated switches are all mounted on a pipe framework located at a central point in the boiler room.

Each boiler has a Crosby steam gage and in addition there is a 24-in. dual face illuminated gage built by the Schade Valve Mfg. Co., which is so placed in the boiler room that it may be seen from practically all points. The large gage shows the main steam header pressure and indicates at once, due to the large scale, any fluctuations accounted for by changes in load.

Through the use of these various instruments and the combustion control apparatus, it is possible to maintain boiler room operations on the best possible basis for a particular load condition.

Arrangement of equipment in the turbine room is such as will permit accessibility for maintenance work and also make the best use of natural light. It is possible, for instance, to run standard gage railway cars into the turbine room at the ground floor level so that heavy parts can be handled by the station crane. Should replacements be necessary they can therefore be handled with a minimum amount of labor. Through the use of

FIG. 10. MAIN CONTROL ROOM EQUIPMENT CONSISTS OF A BENCH BOARD, METER BOARD AND RELAY BOARD

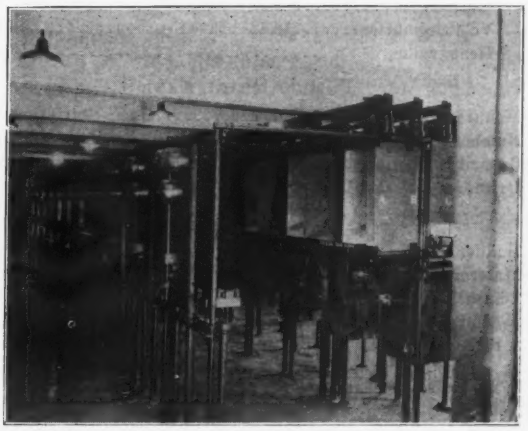


FIG. 11. STATION AUXILIARIES ARE OPERATED BY REMOTE CONTROLLED SWITCHES LOCATED IN THIS ROOM

FIG. 12. COAL IS DELIVERED TO THE BUNKER BY AN AUTOMATICALLY OPERATED BALANCED SKIP HOIST

Summary of Mechanical Equipment in Barbadoes Island Plant

Boilers

Manufacturer.....Springfield Boiler Co.
Number 3
Working pressure.....300 lb.
Water heating surface.....16,800 sq. ft.
Furnace volume ..... 4,970 cu. ft.
Ratio furnace volume to water heating surface..... .295
Ratio superheating surface to boiler heating surface..... .101

Stokers

Manufacturer.....Westinghouse Elec. & Mfg. Co.
Number 3
Retorts 12
Grate area projected..... 287.54 sq. ft.
Ratio water heating surface to grate area..... 58.4
Ratio furnace volume to projected grate area..... 17.3
Drive..... adjustable speed d.c. motor through Morse chain.
Proximate analysis of coal used—
Moisture ..... 3.59 Ash 9.66
Volatile matter.....18.92 Fixed carbon.....67.83
Heat value, B.t.u.....13,423

Forced Draft Fans

Manufacturer .....B. F. Sturtevant Co.
Number 3
Capacity at 7 in. static pressure.....65,000 cu. ft. per min.
Drive.....Westinghouse turbine 119 hp. at 1280 r.p.m.

Stack

Builder .....Sotter Bros.
Material.....Steel with 4-in. brick lining
Dimensions—
Height above grate.....300 ft.
Diameter at breeching ..... 24 ft.
Diameter at top ..... 18 ft.

Boiler Setting

Boiler insulation .....Sil-O-Cel
Murray setting in casing.

Turbo-Generators

Manufacturer.....Westinghouse Elec. & Mfg. Co.
Number of units.....2 Rating .....20,000 kw.
Generator.....13,900 v., 3 phase, 60 cyc., 1800 r.p.m.
Steam at throttle.....250 lb. Temp. .....625 deg. F.
Guaranteed performance on 28 stage semi-double flow unit at 285 lb. steam, 200 deg. F. superheat and 28.5 in. vacuum.

Load kw.	Water rate lb. per kw. hr.
10,000	11.5
16,000	10.7
20,000	10.85
22,500	11.08

Generator Cooling

Closed system.....75,000 cu. ft. min.
Spray type washer.....Cooling Tower Co.
Pumps....2—600 g.p.m., 90-ft. head, driven by 25-hp. motor
Manufacturer .....Dayton-Dowd Co.

Condensers

Manufacturer .....Westinghouse Elec. & Mfg. Co.
Number of tubes.....7640—1 in. diam., 20 ft. long
Material of tubes.....Muntz metal
Total tube surface.....40,000 sq. ft.
Over all dimensions—
29 ft. 3 in. wide, 16 ft. 6 in. wide, 24 ft. 2 in. high
Capacity in pounds steam per hr. at 28.5 in. vacuum, 60 deg. F. water.....270,000
Cooling water per lb. of steam.....5.77 gal.
Steam condensed per sq. ft. of tube surface..6.75 lb. per hr.
Air removal..Westinghouse Le Blanc motor driven air pump—75-hp., 2300-v., 700-r.p.m. squirrel cage induction motor
Circulating pumps.....2—24,000 g.p.m. per condenser each driven by 175-hp., 500-r.p.m., 2300-v. squirrel cage motors
External head..... 6 ft. Suction lift.....10 ft.
Condensate pumps.....1—800-g.p.m. each condenser driven by 50-hp., 1750-r.p.m., 2300-v. squirrel cage motor
Discharge head....85 ft. Submergence head....3½ ft.
Ejectors .....1—4-in. jet for priming

Feed Water Heaters

Boiler feed water, open type metering heater 600,000 lb. per hr. .....H. S. B. W.-Cochrane Corp.
Evaporator feed water, open type, 12,000 lb. per hr.....
.....Griscom-Russell Co.

Evaporators

Manufacturer.....Griscom-Russell Co.
Type.....Double effect, coil Capacity....12,000 lb. per hr.
Pumps..Duplex, horizontal, Worthington Pump & Machy. Corp.

Boiler Feed Pumps

Manufacturer .....Cameron Pump Co.
Type .....Centrifugal Number installed.....2
Capacity .....1000 g.p.m. at 1950 r.p.m.

Service Pumps

One.....500 g.p.m., 1750 r.p.m. Worthington centrifugal
One.....300 g.p.m., 1750 r.p.m. Cameron centrifugal

Fire Pumps

One.....500 g.p.m., 1750 r.p.m. Worthington centrifugal

Miscellaneous Equipment

Steel grating.....Kerlow Steel Grating Co.
Boiler damper control.....Ruggles-Klingemann Co.
Edwards blow-off valves.....Everlasting blow-off cocks
Boiler stop and check valves.....Edwards Valve & Mfg. Co.
Safety valves.....Consolidated Form D. S.
Soot blowers, valve-in-head.....Diamond Power Specialty Co.
High pressure steam and water fittings, Nelson Valve & Mfg. Co.
High pressure steam gate valves.....Nelson
High pressure steam joints.....Garlock ring type
Pipe covering.....American Insulation Co.
Oil filtration.....Richardson-Phoenix Co.
Feed water regulators.....Williams Gauge Co.
Alarm columns, cast steel monel metal fittings.....
.....Williams Gauge Co.
Expansion joints on circulating water lines..U. S. Rubber Co.
Expansion joints on exhaust lines.....George F. Ott Co.
Heating drips return system.....Nash Engineering Co.
Venturi meter, Simplex on condensate discharge.....
.....300,000 lb. per hr.
Atmospheric relief valves, 1—20-in. multiport, H. S. B. W.-Cochrane Corp., and 1—36-in. multiport, Atwood-Morrill Co.
Crane, 50-T. double girder.....Niles
Steam gages.....Crosby Steam Gage & Valve Mfg. Co.
Master steam gage.....Schade Valve Mfg. Co.
Steam flow meters.....Bailey Meter Co.
CO_2 meters.....Republic Flow Meters Co.
Draft gages.....Precision Instrument Co.
Recording thermometers.....Foxboro Co.
Indicating thermometers.....Taylor Instrument Co.
Mercury columns.....Precision Instrument Co.
Coal handling system.....
R. H. Beaumont Co., and Robbins Conveying Belt Co.
Ash gates.....Baker-Dunbar Co.
Intake screens.....Chain Belt Co.

pedestal type foundations for the turbines and steel grating floors at the operating floor level it has been possible to secure a well lighted basement floor for auxiliaries and one which gives a maximum degree of accessibility when using the crane.

As previously mentioned, the initial section of the plant is laid out for two 20,000-kw. units, one of which is already in operation and the second is now being installed. The first machine is semi-double flow 28-stage type with a guaranteed performance as given in the tabulation of equipment accompanying this article.

Generation is at 13,900 v. at 1800 r.p.m. and at 80 per cent power factor the amperage per phase is 1040. A closed system of ventilation supplying 75,000 cu. ft. of air per minute is used for generator cooling. The air conditioning equipment was furnished by the Cooling Tower Co.

Each generator is provided with its own 100-kw., 250-v. exciter direct connected to the main shaft. In addition, there is a 150-kw. motor-generator set which may be used in an emergency. This set is driven by energy from the house service buses.

Each turbine is served by a Westinghouse surface condenser with 40,000 sq. ft. of condensing surface. These condensers are rigidly connected to the turbines, expansion being taken care of by spring supports.

With 28.5 in. vacuum and 60 deg. F. cooling water, the condenser of the first unit is guaranteed to handle 270,000 lb. of steam per hour, using 5.77 gal. of cooling water per pound of steam.

Double Drive for Circulating Pumps

Cooling water for each condenser is supplied by two 24,000-g.p.m. centrifugal pumps which are driven by a 175-hp., 2300-v. direct connected motor on one end and a direct connected turbine on the other end. As the condensers are the divided water box type, either or both pumps may be used to supply water to either one or both of the water boxes.

With this arrangement, considerable flexibility is obtained and it is possible to clean one-half of a condenser at a time without interrupting service. Present practice calls for cleaning the tubes weekly.

Condensate from each condenser is taken care of by an 800-g.p.m., 1700-r.p.m. Emerson centrifugal pump driven by a 50-hp., 2300-v. Westinghouse motor. The dry vacuum pump is of the low speed Le Blanc hydraulic type. This pump is driven by a 75-hp., 100-r.p.m., 2300-v. motor.

It is interesting to note that all of these pump motors, including the other station 2300-v. auxiliary motors, are started by throwing them on an 1100-v. starting bus. The control is of the push button type; all switches being located in the house service switch room. Two sets of leads, one 1100 v. and the other 2300 v. are carried to each motor and all changes from one circuit to the other are made by the remote control. Through the use of an interlocking arrangement it is not possible to throw a motor onto the starting bus before throwing it in the running position nor is it possible to make the change in connections before the current value has dropped to a predetermined point.

Circulating pumps and the house service pumps are primed with a steam ejector while the air pumps are primed from the main circulating water or with the steam ejector.

Suction lines are sealed by running them in water filled trenches in the floor. This method serves the double purpose of sealing the suction lines and also provides drainage channels at times of high water. As the auxiliary floor is below the flood level stage, a sump pump is installed to take care of any leakage through the foundation walls.

Building Is Constructed of Tile

One marked feature of interest in connection with the design of the building is the use of tile construction. So far as is known this is the first power station to utilize this type of construction. This construction consists of a steel frame work with curtain walls made of 8-in. tile and with terra-cotta belt courses and cornices.

Monitor type roof construction is used with 4-in. concrete slabs over the boiler room and 3½-in. gypsum slabs over the turbine room. Both the concrete and gypsum are covered with Carey asphalt.

Ultimately the turbine room will be 388 ft. long and the boiler room 321 ft. in length. At present, however, the turbine room measures 176 ft. 3 in. in length by 49 ft. 8 in. wide, with a height of 78 ft. 4 in. The boiler room is 128 ft. 6 in. long, 61 ft. 6 in. wide and 84 ft. high.

Concrete is used for the basement floor and also for the boiler room operating floor, while the operating floor in the turbine room consists partly of Kerlow steel grating and partly concrete. All floors above the operating floor are steel grating.

All window sashes are motor operated and constructed of rolled steel with 12 by 18-in. window lights of rough wire-glass ¼ inch thick. Extending longitudinally over the boiler house is a saw-tooth skylight 15 ft. wide. The roof is made up of corrugated wire glass and the saw-tooth face consists of continuous steel sash.

Ample artificial illumination is provided by some 300 enameled steel reflector lighting units which are supported by ½-in. pipe. The total station lighting load is 41 kw.

That portion of the building utilized for the electrical control apparatus consists of a wing joined to the main part of the station. There are three floors which in the particular section shown in Fig. 1 are marked control room, conduit room and battery room. Other rooms on these floors are bus rooms and the switchroom for the house service.

As shown in Fig. 10, the main station switchboard is quite simple in its layout. It is arranged in semi-circular form with the bench board forming the inner circle, meter board next, and the relay board the outer circle with passageways in between. There are three bench board sections and 13 relay panels. The bench board is made up of a slate top with front and end sections also of slate and a grill work in the rear. The meter and relay boards are also of slate which is finished in natural black. All of this equipment was furnished by the Westinghouse Electric & Manufacturing Co.

In the preparation of this article, we are indebted to J. A. P. Crisfield, vice-president; E. B. Severs, chief designing engineer, and H. L. Moody, sales manager electrical department, of the U. G. I Contracting Co., of Philadelphia, for assistance in collecting the data about the station. This organization handled both the design and erection of the plant.

Oil as Fuel in Industrial Power Plants

How Practical and Economic Considerations Affect the Use and Selection of Fuel. By Douglas Henderson*

IT IS ALWAYS interesting to read the information that becomes available from time to time on the subject of oil burning in small boiler plants, but most of it is written from the viewpoint of what can be done rather than what has been done. Occasionally there are published the results of some test that has been

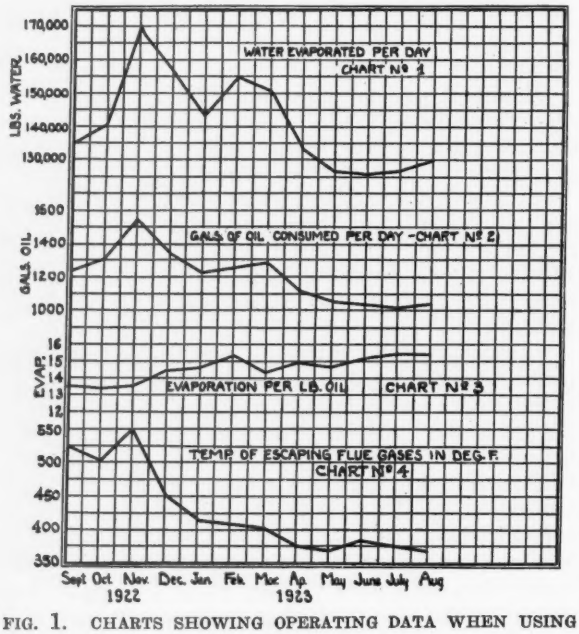

LBS. WATER
WATER EVAPORATED PER DAY
CHART No 1
GALS. OIL
GALS OF OIL CONSUMED PER DAY - CHART No 2
EVAP.
EVAPORATION PER LB. OIL CHART No 3
TEMP OF ESCAPING FLUE GASES IN DEG F.
CHART No 4
Sept Oct Nov Dec Jan Feb Mar Ap May June July Aug
1922
1923

FIG. 1. CHARTS SHOWING OPERATING DATA WHEN USING OIL FOR FUEL

conducted at a certain plant and it naturally contributes a great deal of useful and important data.

This article presents the subject in what might be termed the "past tense," for it represents what has been accomplished at a small industrial plant located in New Jersey which has been under constant observation for the period of one year. To give the reader an idea of the size of this plant, it can be described as having four return tubular boilers, each with 1500 sq. ft. of heating surface. To carry the load, only two units are required at any given time, thus leaving two others off the line for cleaning and inspection. This combination permits the thorough overhauling of each unit and when a boiler goes back into service it is clean internally beyond a shadow of a doubt. The steam generated is used to drive steam engines, pumps, other small auxiliaries, and also a good portion is used in process work for drying, and evaporating.

All of the boilers are equipped with oil burners and furnaces, the change from coal having been made about 2 yr. ago. To keep a close check on the boiler operation, several important instruments have been provided. These comprise CO_2 recorders, recording flue gas thermometers, feed water thermometer, recording pressure gage, and steam flow meters which record all of the steam produced. The oil consumption is recorded daily in gallons and twice per month the oil is sampled and tested. From the instrument records and the oil analyses, all the information necessary is gathered to provide continuous supervision of operation.

For five days of each week, the load is of 24-hr. duration. On Saturday and Sunday, the usual light load of the weekend is carried. Each day the records are averaged and the figure thus obtained is recorded so that by the end of the month a series of entries is on hand from which an average can be computed. This average represents actual every-day operation and for that reason it is far more valuable than any set of test figures that might be collected.

Method of Checking Variations

Each month a "heat balance" is constructed for this boiler plant that shows exactly what becomes of the heat in the oil that is fired. The quantities in the heat balance are expressed in percentages of the total heat in 1 lb. of the oil. A typical heat balance appears below:

	Per cent
Heat absorbed by the boiler	81.2
Loss of heat up the stack	6.1
Loss due to hydrogen in oil	7.5
Radiation and unaccounted for	5.2
	100.0

Value of the heat balance lies in the fact that errors can be picked up quickly if the figures do not balance. For example, were the evaporation per pound of oil to be such that a high figure for the combined efficiency would result, the heat balance might easily total more than 100 per cent without any allowance for a radiation loss. This means that there is greater probability that an error has been made either in the water weights or the oil figures rather than in any of the computed losses. For a given plant operating under the same conditions each day the radiation loss will remain a constant quantity so that if for any one month it shows a wide variation from the normal it is an indication that errors in observations have entered the computations. The often neglected "radiation and unaccounted for" loss is quite an important one in any well established heat balance, for it tells the observer a great deal about the accuracy of the figures.

From the steam flow meters at this plant it is possible to develop a daily figure for the water evaporated. The daily average for each month has been plotted, Fig. 1, in order to provide a means of visualizing the plant load with its seasonal variations. The average steam generated daily has been converted into the number of pounds of water evaporated per pound of oil burned which has also been plotted. Here it can be seen that a marked improvement in evaporation took place about the first of the year 1923, increasing from about 13.5 lb. to something over 15.0 lb. To learn the reason for this improvement, other graphs have been included showing variation of CO_2 percentages, B.t.u. per pound of oil, temperatures of escaping gases, and finally combined efficiency of the boiler plant.

*Chief Engineer, Fuel Engineering Co.

In looking over these graphs, it will be noticed that the months of September, October, and November, 1922, were distinctly inferior in results to those months that follow. The CO_2 record, for example, jumps from about 9 per cent up to 13 per cent and over, while the flue gas temperatures decreased from 525 deg. F. to 375 deg. F. Part of the reduction in flue gas temperature can be ascribed to falling off of the load and a gradual reduction in boiler rating, but that is not the only reason for the lowering of the exit temperatures.

This plant was originally equipped with burners of a certain make, but in December another system of oil burning was installed under each boiler. The change was made about the middle of December, which accounts for the better results during that month. The following months showed a remarkable improvement all due to better combustion conditions. The new system carried with it a complete change in furnace design thus gaining a better mixture of the air supply with the atomized oil. The improvement in the percentage of CO_2 together with a reduction in temperature of the escaping gases caused the combined efficiency to increase as the chart indicates. This in turn had a good effect upon the evaporation per pound of oil, raising it from 13.5 to 15. The most interesting effect of the change in burner equipment was on the cost of generating 1000 lb. steam. This cost is based upon the oil at $0.04 per gal. which was the contract price for the period covered by this survey. It can be seen from the graph that for September, October, and November, 1922, the cost per 1000 lb. of steam was between $0.36 and $0.37, while for the months following the cost dropped as low as 0.32.

Comparison of Fuel Costs

This plant offers a concrete example of the much debated question of coal vs. oil as a fuel. It is a matter of common knowledge, now, that each case must be considered separately and a decision made accordingly. In other words, it is impossible to make a blanket statement on this question that will apply to all plants because of the variation in oil price, coal cost, and load conditions. The management of this particular plant raised the question as to the relative value of coal and oil at their plant and a chart was drawn up to demonstrate which of the two fuels would be the more economical.

This plant can buy at the present market price, a good semi-bituminous coal delivered at $6.22 per net ton. Operating as they do with the necessary instruments to guide them, it is entirely possible for the efficiency when using coal to average 68 per cent. This will vary from month to month just as it has done with oil, but for an average figure this is conservative. The horizontal line on the chart represents the cost per 1000 lb. steam as generated by burning coal at this price and with this efficiency. In actual figures it amounts to $0.345 per 1000 lb. The part of the cost curve which has been shaded shows the duration of the operation using oil as a fuel when the plant actually lost money, but immediately after the change in equipment took place, the cost per 1000 lb. steam fell below the cost computed for burning coal. Therefore up until August, 1923, the use of oil at $0.04 per gal. has been a paying proposition.

Recent quotations of oil and the price that will have to be paid under the new contract will be $0.05 per gal. and this increase of one cent per gallon is sufficient to change the aspect of the whole problem. The dotted curve has been constructed using $0.05 per gal. and it lies well above the actual cost based on four cent oil. It also is considerably above the straight line representing the cost if coal were used, so that the increase in price of oil has made conditions such that coal is actually to be favored.

This conclusion is reached based on the fuel value alone, but there are other factors to be taken into consideration. First of these is the fire-room labor. This

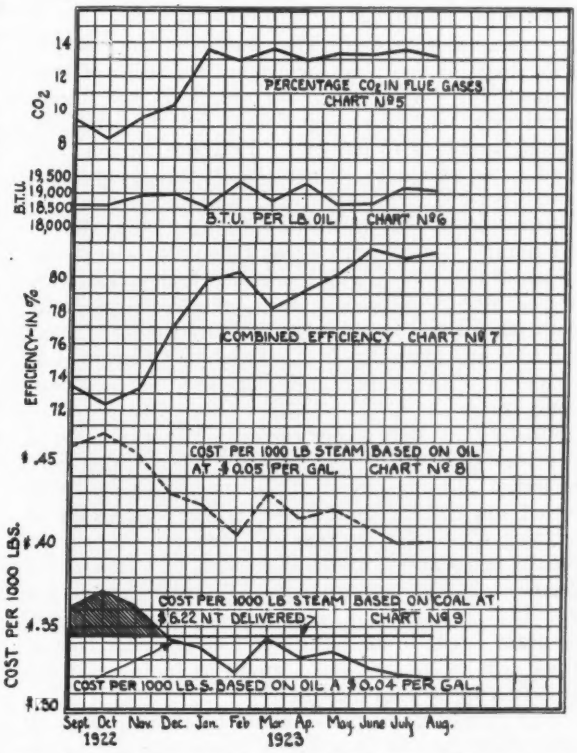


FIG. 2. CHARTS SHOWING COMPARATIVE COST OF COAL AND OIL FOR FUEL

plant is of such size that only one fireman is required per shift, and whether the fuel be coal or oil this item can not be changed. Consequently the labor side of the question did not enter into the ultimate decision at all. The next factor is the cost of handling coal and ashes, which is a charge to be made over and above the cost of the fuel itself, and a charge which does not exist at the present time. Computing the relative cost of coal as against oil, with oil at five cents per gallon, it amounts to $7.25 per net ton. That is the price at which coal must sell before oil at five cents can be directly comparable. The difference between this price and the actual coal cost of $6.22 is $1.03 per T. to cover coal and ash handling.

When these charges are deducted the difference in favor of coal is small, in fact, it is doubtful whether any differential will exist at all. After due consideration of all the facts in the case, the management of this plant decided to continue with oil at five cents per gallon for they placed sufficient value upon the cleanliness of oil

and the ease with which it can be handled to overcome any advantages in price that the coal had. This was simply a matter of policy.

Facts disclosed in this article set forth two or three rather important phases in the use of oil as a fuel in industrial power plants. In the first place, it emphasizes very nicely that there is a wide difference in oil burning systems and that it is highly important that enough information be gathered to make sure that the best operation is being obtained. Just because there are no ashes to handle when using oil does not mean that it develops high efficiency of operation automatically. It should be remembered that oil requires more attention to get the best results than coal for the simple reason that oil must be burned at high efficiencies or else it cannot compete with coal. The analysis of the cost per 100 lb. steam at this plant brings out the truth of that statement, for during 3 mo. the use of oil was uneconomical even though during those 3 mo. the combined efficiency averaged 73 per cent. That was too low, and it had to be raised to 80 per cent to represent satisfactory operation from a financial standpoint.

Operation can be watched and brought up to the desired point in only one way and that is through the medium of boiler room instruments. The few that were installed at this plant have paid for themselves many times over not only in aiding to bring up the plant operation to a satisfactory point, but also to maintain it at that point. The charts show how well this has been accomplished.

Finally, the effect of one cent per gallon increase in the price of oil can be seen directly from the graphs. The cost of oil at five cents and the price of coal at $6.22 per net ton brings about a very close comparison of operating costs, so close that the management has decided in favor of oil, but this would not be true if the efficiency when using oil had not been raised to 80 per cent. It is true also that under the conditions that exist, this plant ought to operate their boilers under coal at 70 per cent efficiency, which would be in favor of the latter fuel by a wide margin.

Experience at this plant should be of interest to all plants using fuel oil in a region where coal can be delivered fairly cheap. It shows clearly the effect of efficiency on the whole problem of oil burning, and furthermore it demonstrates the necessity of maintaining high operating efficiencies if the use of oil is to be economical.

MAKING LAP-WELDED PIPE by hammer-welding is relatively new as compared with the butt-weld and lap-weld process, and the sizes made by hammer-welding are relatively much larger in diameter. Manufactured in sizes from 24 to 96 in. and in various wall thicknesses, this pipe is adapted for practically all purposes where large diameter pipe is required.

The pipe is made by bending a steel plate into tubular form with edges overlapping, and then welding the overlapped edges after they have been heated by hammer-forging them on an anvil block supported on a horn inside the pipe. Due to the simplicity of manufacture —in that rivets, projecting ribs, and other objectionable features are eliminated—hammer-weld pipe has a relatively high efficiency.

Its large fields of service are for water, gas, steam and various types of pumping or power plant installations.

What Is the Arc of Contact?*

BY W. F. SCHAPHORST

HERE is a chart that will instantly give the degrees of belt contact in any belt drive, knowing the number of inches of belt in contact and knowing the circumference of the pulley in inches.

For example, if 30 in. of the belt makes contact with the pulley and if the circumference of the pulley is 60 in., how many degrees are in contact?

Simply lay a straightedge or stretch a thread across the chart connecting the 30, Column A, with the 60, Column C, and the intersection with Column B gives the answer as 180 deg. The drawing on the chart will assist the user so that it will not be necessary for him

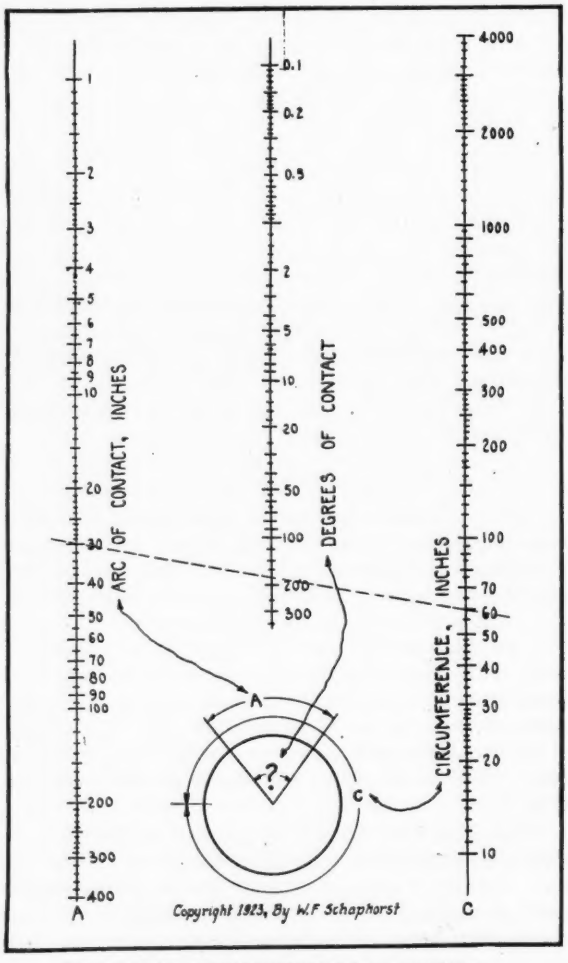


CHART FOR DETERMINING ARC OF CONTACT

to read the words along the columns each time the chart is used, as the wavy arrows lead from the known and unknown quantities to the proper column. That is, A equals arc of contact in inches; C equals circumference in inches, and the question mark, which is the unknown quantity, the degrees of contact.

Of course, it is not necessary to make measurements in inches. They can be made in feet, yards, metres, centimetres or any other desired unit of measurement.

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Making Leather Belts Endless

MAKING A BELT ENDLESS IS REMARKABLY SIMPLE AND CAN BE DONE BY ANY HANDY MAN IN THE SHOP. BY LOUIS W. ARNY

ONE OF THE most important things in the installation of belts for power transmission is the method employed in making the joint. As is evident, the weak point of every belt, regardless of type or size, is the joint, and it is this joint which is responsible for most of the belt trouble.

There are upon the market numerous devices for joining the two ends of a belt and while many of these

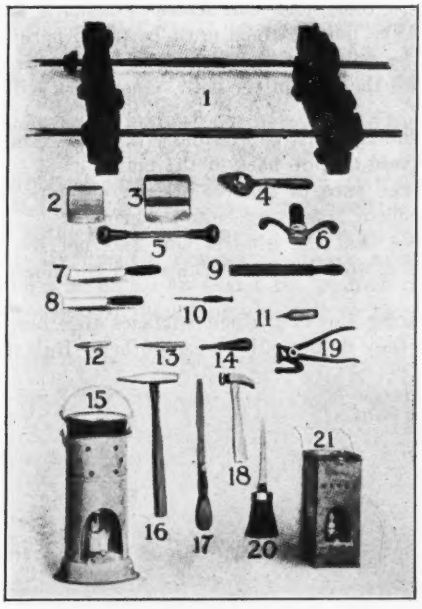


FIG. 1. THE TOOLS REQUIRED IN MAKING BELTS ENDLESS

are effective and give good service when properly installed, they are on the whole subject to the following objections: they break; they tear out the ends of the belt; if metal, they clatter in going over the pulley; if of leather, they form a hump which pounds on the pulley; they may constitute a source of danger to workmen; as a rule, they require frequent renewal, and if not carefully adjusted, they make probable a crook in the belt at the joint.

These are all serious defects, small in themselves, perhaps, but aggregating, where there are many belts, a large amount of lost time and annoyance. "The total depravity of inanimate things" always causes belt fastenings to fail at the most inopportune time, when the loss and the annoyance are greatest. Of course, belt fasteners are extremely handy in making a quick joint and for some classes of work are sufficiently satisfactory.

To secure freedom from the above-mentioned troubles, however, the only remedy lies in the use of endless belts; that is, those in which the two ends of the belt are joined to make a continuous length. Almost any kind of belt can be made endless at the factory by the manufacturer who made it, and where an endless belt can be placed around the pulleys without an expenditure of two much time and effort, and where there is provision for taking up the stretch, new belts should be ordered "made endless" when purchased.

Where it is necessary to take down shafting and pulleys to install such a belt, or where there is no provision for taking up the stretch, a belt made endless at the factory cannot be used. Some kinds of belts can be made endless on the pulleys satisfactorily while other kinds can not. The belts referred to in this paper are all of the type which can be made endless on the pulleys satisfactorily; in other words, leather belts.

A Simple Job

Making a belt endless on the pulleys is like many another job, in that it appears difficult and complicated;

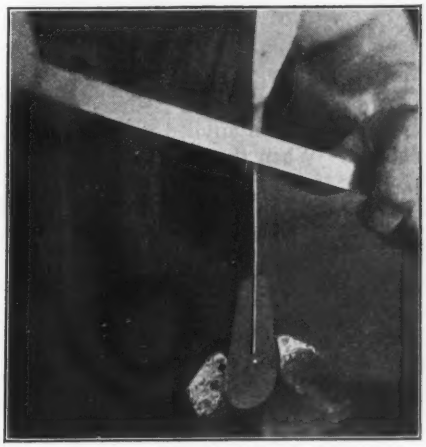


FIG. 2. TURNING THE EDGE OF THE SCRAPER

but when once the trick is learned, it is remarkably simple, and the handy man of the shop, or any man accustomed to use carpenter tools, can learn it, and can make all the belts in the shop endless, and "take them up" when occasion requires, besides making any other repairs that may be necessary. The aggregate cost of making and maintaining endless belts will not be materially different from the cost of using fasteners.

Tools Required

Tools required are shown in Fig. 1 and are as follows:

1. Clamps and Rods.
2. Belt Scraper.
3. Slicker.
4. Belt Hoe.
5. Belt Shave.
6. Spoke Shave.
7. Long Skiver.
8. Heel Chop.
9. Knife Sharpener.
10. Steel Sharpener.
11. Awl.
12. Drive Punch.
13. Blind Punch.
14. Staple Puller.
15. Glue Kettle.
16. Ripping Hammer.
17. Screwdriver.
18. Pegging Hammer.
19. Hand Punch.
20. 3½-in. Best Glue Brush.
21. Safety Copper Glue Kettle.

Some of these tools are already in the shop, but if not, may readily be obtained at a reasonable cost. There is only one of them that is unusual to the ordinary me-

chanic—the turned edge scraper. This is a flat piece of good steel, about the thickness and quality of good saw steel, and is fitted in a handle as shown. The point about this tool is that it works with an edge which is turned at a right angle to the blade. This is accomplished by grinding a long edge, then rubbing this down to a fine edge on a "clearing stone," then with a smooth, hard, steel tool, turning this edge so that its cutting edge is at right angles to the blade. With the tool firmly

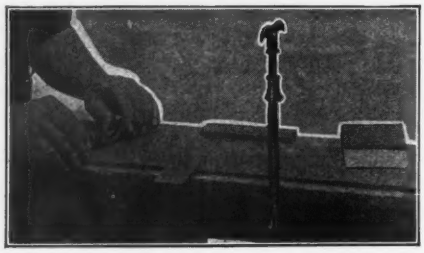


FIG. 3. THE HEEL OF THE LAP HAS BEEN MARKED WITH THE SQUARE AND ROUGH CUTTING IS BEING DONE WITH THE SPOKESHAVE

held in a vise, pressure is applied on one side, about at the angle shown. When the edge is smoothly and uniformly turned to the angle shown, the angle of the steel tool is changed, and the process repeated, and then is completed by using the steel tool at right angles to the blade.

There is a small steel tool, Number 10 in the illustration, round, slightly tapered, with a smooth, hard point, which is used to keep this turned edge in good cutting condition, by rubbing its point on the under side of the turned edge, and its surface on the upper side. These turned edges are fairly durable, in working in leather, but when they are gone it is necessary to grind the tool again, and repeat the process of form-

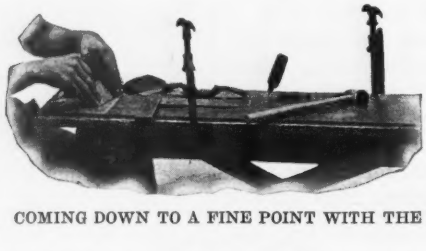


FIG. 4. COMING DOWN TO A FINE POINT WITH THE SCRAPER

ing the edge. The scraper is one of the most important tools in the belt maker's kit, because it saves much time in cutting laps, and because with its use it is possible to scrape down a lap to an even bevel, and to make sharp points on the laps.

Making Laps

First decide on the length of the lap desired. Generally speaking, it is wise to make a new lap of the same length as the others in the belt, though in the case of double belts this may be varied to suit the conditions. One lap should not be made over another lap, and it may be necessary to make a lap longer or shorter to avoid this. The things to be remembered are that the line of the point and the line of the heel must be exactly square with the edge of the belt, and that the bevel from heel to point must be uniform and regular, and that there must be no "humps," especially back of the point, to prevent the proper adhesion of the cement at every point of contact.

Clamp the belt to the table, so that both hands are free for the use of tools. Measure the lap desired, and mark across the belt a line drawn with the use of the square, as representing the end or heel of the lap, and proceed with the spokeshave to cut away the material from this line down to the end of the belt, the latter becoming the point of the lap. This should be "roughed off" with the spokeshave, and then scraped down to the point with the scraper, and trimmed up with the knife, as illustrated. A small steel plane also can be used to advantage in connection with the spokeshave. Any man handy with tools soon can learn to make a good lap quickly. The points which must be noted here are:

(a) The points of the laps always must be exactly square with the edge of the belt. Guesswork will not do here.

(b) The lap must be gradually tapered from heel to point. Avoid a lump back of the point.

(c) Take care to remove all the old glue, and to present a clean, fresh surface to the cement.

(d) See that the glue is hot, and not too heavy; spread thin, working it carefully into the fibers of the leather.

(e) Bring the two glued surfaces together, taking care that they do not slip on each other. Rub the joint

FIG. 5. WORKING DOWN TO A ROUGH POINT

with a scraper handle to supply a little pressure, or place the joint between two small boards and apply pressure with the bench clamps.

(f) Permit the glue to "set" for an hour, before putting the belt on the pulley.

Classes of Belts to Be Made Endless

Belts which are to be made endless will divide themselves into three classes:

First—Those which have been endless, and which it is desired to shorten.

Second—Those which have been running with a laced or metal fastened joint.

Third—New belts which have not yet been placed upon the pulleys.

These again divide themselves into two classes:

(a) Those which are small enough to throw off the pulley, and to take to a nearby bench, and

(b) Those which, because of their size, must be worked upon on the pulleys.

To Shorten Narrow Belts Which Have Been Endless

With the first of these classes the belt has been running endless, but has stretched a little, so that the ten-

sion is reduced and it becomes desirable to shorten it. If it is a narrow belt, which easily may be thrown on the pulley, it first is necessary to determine how much shorter the belt must be. When this is decided, find the joint which was made when the belt was last put on and, with the point of the screwdriver, carefully open it, running the screwdriver under the point of the lap and working it towards the heel, taking care not to tear the leather.

If it is a double belt each ply of leather may have its own lap, or if it is a narrow belt it may have such a lap as is used on a single belt. Remove the belt to the bench; inspect carefully to see from which end it is most desirable to cut, in its relation to any other joints in the belt, and then bring the end on which it is decided to work nearly to the end of the bench, clamp the belt to the bench with bench clamps, and proceed to cut back the laps the desired distance.

To Make an Endless Joint in a Belt Which Has Been Laced or Hooked

Where it is desired to substitute an endless joint for a laced or hooked joint the procedure is a little different. If the belt is loose enough on the pulleys so that it can be tightened a number of inches equivalent to the number required to make the endless joint, the process consists in removing the belt to the bench as

FIG. 6. FINISHING THE TIP OF THE POINT WITH A KNIFE

before, and making the necessary lap. If it is a single leather belt, or if it is a narrow double, say under 6 in., an ordinary single lap may be used as illustrated. This lap should be from 4 in. to 6 in. long, according to the width. The process then may be completed as described. If the belt is an old one, and the surface of the lap when made appears to be greasy, it should be cleaned with gasoline before attempting to cement it.

Where the belt is not long enough to provide from its stretch sufficient material for the lap, it becomes necessary to prepare a piece to set into the belt. If it is a single belt, this may be a very short piece with a lap on each end, as illustrated, and then laps must be cut upon the old belt to fit this piece, and the cementing process applied as described. Where it is a narrow, double belt, the piece inserted may be made in exactly the same way; but for a wider double belt, the piece should be arranged so that it provides a separate joint for each of the two piles of the double belt, and that these two joints are "broken" so that they do not come together. This type of joint is illustrated. The ends of the belt then may be fitted to this insert.

Wider Belts Which Cannot Conveniently Be Carried to the Bench

If it is an old belt that is to be shortened, first find the point on the belt at which the joint has been made, and bring the belt around to a place between the two pulleys where it may be most convenient to work. Then put on the clamps, one of the jaws above and one below the joint.

In putting on belts with clamps the first requisite is to see that the middle line of the width of the belt corresponds exactly with the middle line of the distance between the centers of the rods of the clamps. Most clamps have this point marked on them. The next point, and a most imperative one, is that each pair of jaws of the clamps shall be exactly square with the edges of the belt. A little care here in drawing up evenly on the

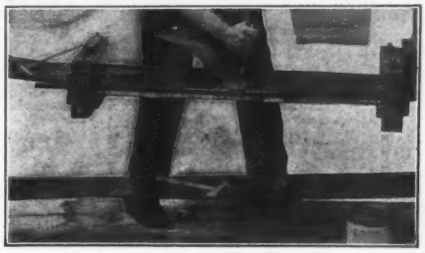


FIG. 7. SPREAD THE CEMENT, HOT AND THIN, WORKING IT WELL INTO THE FIBERS

two rods will bring the two ends of the belt square and true, and will save effort and possibly a crooked belt.

Apply enough pressure to the clamps to take the tension of the belt off the joint, and then open the joint with the screwdriver, as before, cut down the new lap on one end with the spokeshave and the scraper, scrape off all the old glue from the lap on the other end, and proceed as before. This work can be best done on a clamp board, which fits between the rods and is attached to them.

Making New Belts Endless

In putting on new belts the laps should be made and the belt drawn over the pulleys, and then the clamps adjusted as above described. If the belt is to be bought, give the belt maker the exact length around the pulleys, stating whether it has been measured with a steel tape, a cotton tape, or a string, and let him make the allow-

FIG. 8. RUBBING DOWN THE SURFACE TO MAKE THE CEMENT ADHERE

ances, and tell him to make it "endless-open laps." It then will come to hand ready to be placed around the pulleys and cemented. In the case of new belts which it is desired to place on the pulleys endless, the first thing is to get the proper length of the belt. It is usual to estimate that the belt should be $\frac{1}{8}$ in. to the foot, or 1 per cent less than the actual steel tape measure around the pulleys, and for small belts, which are to be thrown on the pulleys, without the use of clamps, this will be found to be sufficiently accurate. For those belts which are to be put on with clamps, or where it is necessary

that the belt shall be tight to produce tension, this allowance may be increased slightly, but not much. For single belts, to this length must be added the length of one lap, and the belt may be cut to this total length, and the laps prepared and cemented as provided. For double belts, the plies should be opened for a little distance from the ends of the belts. This distance must vary with the width of the belt, and consequently the length of the lap desired, and with any other joints

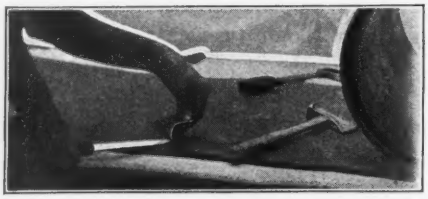


FIG. 9. STARTING A JOINT WITH A SCREWDRIVER

which may be near the ends. It may be desirable to make it long enough on one side of the belt or the other to include an existing lap, so that two of them shall not come close together on the same side of the belt. This distance must be long enough so that each lap will have a piece of whole leather on the opposite side. When this distance is determined, one side of one end must be cut back the proper distance, and the opposite side of the other end. Then the laps may be made on both of the two sides, on both of the two ends, as described. New belts can be prepared best at the bench. If it is a belt of any size it may take some effort to bring the two ends close enough to slip the clamp rods into place. Clamps for very wide belts usually are made with a heavy screw eye bolt in one of each pair of blocks, so that a chain hoist, or a block and tackle may be used to bring the

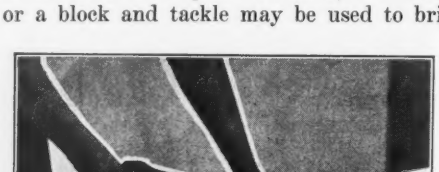


FIG. 10. OPENING A CEMENTED LAP

ends of the belt to a point where the rods may be inserted.

With a new belt it is necessary to pull it up to a point where the laps fit perfectly. Then an observation should be made to see whether the belt is sufficiently tight. There may have been an error in measurement, or an insufficient allowance for stretch. If it is decided that the belt is not tight enough, it is a simple matter to scrape back the laps far enough to tighten it sufficiently, unless there has been a gross error.

There is some sort of agreement among belting men that single belts should be put on so that they have an initial tension, before starting, of 72 lb. per in. of width, and double belts in proportion. Ordinarily, there is at hand no method of measuring this tension, and it becomes a question of judgment of the operator, and he must endeavor to judge accurately the proper tension which should be applied, by watching the performance of his belts after they have been running, and gaging the frequency with which they have to be "taken up."

Cements

There are two kinds of cement used for leather belting, the regular belting cement, and the waterproof belting cement, and both can be obtained from the leather belting manufacturer. Both are of ample strength and durability, one being used for dry, and the other for damp or wet conditions.

Regular Cement

Regular cement usually comes in cakes, or lumps, which are dissolved in water, in a double jacketed glue pot. Any pot with a double jacket, that is, having an inner and an outer vessel, so that the heat reaches the cement through the medium of hot water, and not directly from the flame, will answer, though it is better to use the safety or Underwriter's glue pot, for in it the glue may be maintained under heat directly at the job, and without risk of causing fire. Make the cement hot,

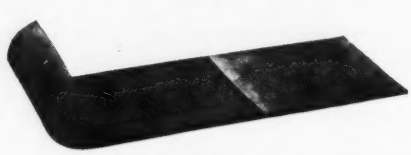


FIG. 11. INSERT FOR SINGLE BELT SHOWING LAPS ON BOTH ENDS

but do not permit it to boil. It should be reduced with hot water to a proper consistency to spread easily, and must be applied "piping" hot, to get the best results. It is desirable, too, that it should be applied fresh, and it is better not to attempt to use over the remains of a previous melting, if it is old and hard. The pot and the brushes must be kept clean, remembering that the base of this cement is animal glue, which is subject to putrefaction.

Waterproofing Belting Cement

Waterproof cement is entirely different. It is chemical, a base dissolved in a solvent other than water. The solvent is extremely volatile, and highly inflammable, and it must be kept away from any open light. It reaches the buyer in a liquid form, usually ready to spread, though after some spreading the remainder will grow thicker and should be reduced by the addition of solvent, which can be had from the same source as the cement.

This cement is more like a varnish, and it is used cold. The surface to be cemented must be thoroughly coated with the cement, well brushed into the fibers of the leather, and then permitted to dry, which, because of the volatility of the solvent, it does rapidly. When dry, apply another coat, spreading lightly, permitting this coat to dry in the same manner. Being perfectly dry, it now is ready for the third and last coat. Be sure to apply evenly, and do not leave any bare spots. On belts wider than 12 in. do not attempt to cover more than a 5-in. cross section of the belt at one time, since the solvent evaporates fast, and it is easier to handle a small surface. When applying the last coat, work fast. Do not hammer the joint, but rub it gently, or place it

between boards, and apply pressure with the bench screws. The joint should "set" for a couple of hours or longer before using the belt.

This waterproof cement substantially is liquid celluloid, and its application places a layer of celluloid between the two surfaces of the lap, in which the leather fibers become embedded. It is unaffected by water, in any period of time, because both its base and its solvent are materials which are not soluble in water. It should be used on all belts that are exposed to damp conditions, or on which water may leak.

Leather Is Waterproof

Leather itself is waterproof—not in the sense that a good oil-skin coat is waterproof, because it does not permit water to penetrate to the clothing beneath, but the leather is waterproof in the sense that though it will absorb water freely, the water does not injure it, and the leather remains substantially unchanged in any amount of water. Leather belts joined with the waterproof cement above described cannot be injured by water. Belts exposed to flood, or to wet conditions, should be kept well dressed with a good animal grease belt dressing to maintain the lubrication of their fibers, and to prevent them from becoming hard when dry.

Both of these cements are thoroughly practicable for their use in belts, without the addition of any rivets, pegs, stitching, or other means intended to hold the plies of the belt together. Thousands of miles of belting are running every day with no other fastening between their plies than one or the other of these cements. Their efficacy has been abundantly proven by many years of experience, hence the addition of rivets or stitching not only is unnecessary, but is a positive disadvantage to the belt in that every hole punched for a rivet, or a stitch, is a source of weakness, and reduces the strength of the belt.

Lubrication

The occasion of taking a belt off the pulley for shortening, or for repairs, always presents the opportunity of making a careful examination of it, more particularly to see that it is being properly lubricated. A good leather belt requires no dressing on its grain, or pulley, side to make it adhere to the pulley, for the natural pulley grip of the leather makes an adhesion with the pulley that is quite sufficient to transmit its rated load, but the leather is composed of thousands of little fibers that are constantly working on each other, and which require lubrication in the same manner as other working parts. It is well to avoid the use of dressings which produce an artificial adhesion between the belt and the pulley, for most of them are injurious, and all of them unnecessary, a suitable lubrication of the fibers of the leather being all that is required.

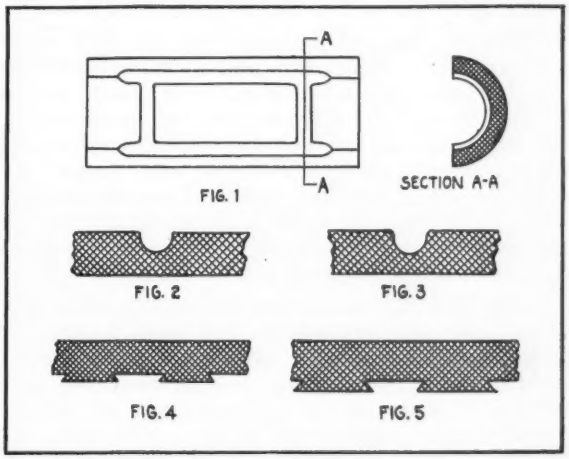
Turbine accidents have occurred from leaving tools, fittings, or other objects inside the machine when closing it up after making repairs. In some machines the various parts could not be properly assembled if any sizable object were left inside, but in all of them there will be spaces in which small objects could be left with corresponding promise of trouble, and the possibility of this should be borne in mind whenever turbines are opened up for repairs or inspection.

Use of Babbit Metal for Bearings

Proper Use of Bearing Metals and Periodic Checks of Machine Alinement Will Reduce Maintenance

MANY USERS of babbit metal feel that it is merely necessary to procure a good grade of metal and their bearing troubles will be over. This result does not always follow because no matter how good the metal may be, if it is carelessly applied it will sooner or later give trouble. For this reason, it is evident that it will pay every engineer to make sure that his bearings are made with due care for all details.

There is a general tendency to groove bearings more than is actually necessary to distribute the lubricant



OIL GROOVES MUST NOT BE LEFT WITH SHARP EDGES

evenly on the bearing surface. An excess of grooving on that portion of the bearing which carries the load will result in an increased pressure per unit of contact area. All grooves should have rounded edges because sharp edges will act as scrapers to destroy the oil film on the shaft. A good point to remember when trying to diagnose bearing trouble is to look for sharp corners on the bearing oil grooves.

When it is necessary to groove the load-carrying part of a two-part bearing, the following method has been found effective: With a boring tool or milling cutter remove the material from both edges of both halves of the bearing except for about ½ in. at each end, as shown in Fig. 1, thus making an oil chamber about ⅛ in. deep on each side, then, at each end of the lower part only, cut a narrow groove parallel to the ends, connecting the two lengthwise recesses.

Alinement of Bearings

Many bearing troubles may be attributed directly to misalinement of machinery. With sufficient patience an average mechanic can make a good job of lining up bearings correctly. It is simply a question of willingness to take the necessary time to do a job in which it pays to be thorough. It is not enough to secure proper alinement when the bearing is first made and then to consider that the job has been completed. It is well to check alinement just before starting up, after all founda-

tions have been finally pulled up. Another check should be made before the bearing has run too long, for in almost all cases realinement will be found necessary, due to unequal wear.

Good grades of babbit should always be used. Special alloys may be necessary for important heavy duty, high pressure bearings. In some cases it will be found advisable to co-operate with the manufacturer of a machine in order to get his recommendation as to the grade and quality of babbit which should be used for certain bearings.

When making an effort to remedy loose liners it will always be well first to examine the anchorage. For bearings subject to severe service, there should be close contact between the container and the liner. Experience has proven that in some cases soldering or tinning is desirable; this can be done in the following manner, using a solder of 50 per cent tin and 50 per cent lead.

When tinning brass shells, the first step to be taken is the removal of grease, dirt, and other foreign matter from the shells by heating them, being careful not to overheat the material of the shell or the subsequent tinning will be difficult. A good way to remove oxide scale and to produce a good, clean surface is to "pickle" the shells in a bath of four parts water and one part muriatic acid. In obstinate cases, the most satisfactory way of preparing the shell for tinning is to machine or grind the surface to insure a clean metallic contact.

After cleaning, the surface should be treated with zinc-chloride soldering solution and warmed either by plunging the shell into a quantity of melted babbit metal or placing it over a fire. In the former case, some babbit will adhere to the prepared face, this can be spread over the surface later with a small brush. In addition to this, the hot face of the shell should be rubbed with a stick of solder and then brushed, which will give a good coating of solder on the prepared surface.

Tinning of steel shells may be accomplished in practically the same way, but care must be used in making the surface to be tinned perfectly clean and free from oil of any kind. Tinning of cast-iron shells is ordinarily difficult, but if sufficient care is taken to file the surface bright just before applying the solder, a good coating may be caused to adhere.

All bearing metal will shrink when cooled. The hotter the metal when poured, the more it has expanded and the more likely it is to make a lining that may not adhere to the backing because of the shrinkage of the metal when it solidifies. Shrinkage of the metal will leave a space into which the metal will be pressed beneath the load. This condition may result in cracking the lining metal and causing it to break.

One cause of a great many poor bearings is the instruction to "heat mandrel and container whenever possible before casting." It does not make so much difference if a low grade bearing metal is cast while it is overheated beeause its high lead content prevents much change in structure during cooling; however, this is not true of the high grade alloys which carry a tin base and a considerable content of copper. A good rule to follow, where durability is desired, is to cast the metal at the lowest heat at which it will be fluid enough to flow into the bearing at one pour, and against surfaces that have been warmed only enough to remove the chill. If the container or mandrel sizzles, when touched with the moistened finger, it is too hot. The more dense and solid the metal's structure, the greater will be its durability. The foregoing principle, if applied, will produce bearings of the best value in density.

Overheating will open the grain or coarsen the structure of babbit metal. It follows that beneath sufficient pressure these particles will be packed together by the weight of the load on the metal. This packing can be avoided if the metal is dense and solid. The density of the metal will be in proportion to its temperature when poured.

Babbit metal must be heated to a higher temperature for large than for small castings. Experimentation in this connection will be repaid many fold in the time saved in rebabbiting.

Immersing removable castings in cold water as soon as the metal has solidified, will increase the density of the metal. In doing this, always be careful to immerse the casting from the bottom upward and do it slowly. The spot at which the metal is poured is always the hottest part of the casting and in cooling should enter the water last. This sudden cooling will close up the grain so that under the pressure and load of service it will not pack or give.

Effect of Bleed Heating on Condenser Surface Requirements*

WITH THE GENERAL trend of practice toward extracting steam from the main unit for heating feed water it would appear, offhand, that less condensing surface would be required due to the lesser amount of steam to be condensed. It is quite likely, however, that such is not necessarily the case since the smaller weight of steam to be handled by the last stages should make it possible to so design the turbine that it can utilize vacuums to advantage. This assumes that the manufacturer has not taken advantage of the steam extracted to reduce the capacity of the last stages. It is doubtful whether any general statement would cover this broad subject, since the questions involved vary with nearly every installation; however, it would appear as though the amount of cooling surface, and consequently the desired vacuum, should be influenced more by the capacity of the lower stages of the turbine, with due regard to cooling water conditions, than by the capacity of the main unit as a whole.

With a given turbine, there is a limit of vacuum above which little or no gain in economy results. Steam extraction raises this limit in any given machine, and it is quite possible that under certain conditions, a larger condenser installation may be justified than would ordinarily be chosen in the absence of bleeding. While the vacuum produced by a given condenser increases with a decrease in the quantity of steam condensed, this is relatively slight in most cases and amounts to about 0.06 in. increase in vacuum for a 10 per cent decrease in the quantity of steam condensed. Whether or not this increase in vacuum would be equal to that which the turbine could profitably utilize would depend upon the design of the exhaust stages of the turbine in question.

*From 1923 Report of Prime Movers Committee, National Electric Light Association.

Cross-Flow Impulse Hydraulic Turbine*

HYDRAULIC TURBINE IS DESIGNED TO FILL THE GAP BETWEEN IMPULSE AND REACTION WHEELS. BY FORREST NAGLER†

TYPES OF impulse wheels now universally adopted are known variously as the Pelton wheel, the tangential wheel, the pressureless wheel, or more generally the impulse wheel. This type, a distinctly American product, perfected by the men of the California mining industry, has superseded all other types for high head work.

It is characterized by:

First—A free jet operating under the full spouting velocity due to the operating head.

Second—Substantially tangential application of the jet to the wheel.

Third—A bucket velocity practically 50 per cent of the jet velocity.

Fourth—Splitter type buckets concave on the working surfaces.

The design developed by the author conforms only to the first item, a requirement inherent in any impulse wheel. Departure from item two is radical, as, in the new high speed types, the jet must always make a large angle with the tangent, hence the name X-flow. The result of this X-flow is to permit of relative wheel velocities comparable with those obtainable with reaction wheels. Wheels have been built and tested having bucket velocities twice and four times those of the present types. With the new type this speed may be increased indefinitely without violating the principles of hydraulics, although mechanical and frictional limitations may introduce restrictions.

The term impulse is commonly used with those wheels in which water is applied to the rotating element in a free jet with all its energy in the form of velocity. It will be so used here, although the term is somewhat of a misnomer as modern impulse wheels develop power as much by reaction as they do by impulse of impact. The term impulse, or perhaps better, impact, might have been accurately used to designate the original current wheels and some of the pioneer forms, such as the hurdy-gurdy wheel, where the water was received on flat surfaces, and no attempt was made to utilize the reaction of the water leaving the wheel. The modern wheel, however, receives the water without shock, completely avoiding what might be called impact, and turns it by a smooth path into a relative direction substantially contrary to that of the motion of the wheel. The essential distinction between the hydraulics of the so-called impulse wheel and the reaction type is found in the fact that in the former, the entire energy of the water received by the wheel is in the form of velocity.

The true impulse wheel should be designated as one in which the water is directed to the wheel with all its energy in the form of velocity or in which the water undergoes no pressure change in the wheel. The essential point of difference between the reaction and impulse turbine is found in the fact that the latter follows the principle of free deviation; that is, the water after leaving the guide passage is allowed to follow its own course in its passage through the wheel and is subjected to no pressure change, and that to permit this the passages of the impulse turbine should never be filled by the water.

According to definition, condition No. 1 is inherent with all impulse wheels. Conditions No. 2, No. 3 and No. 4 dominate the impulse wheel field at present and have done so, with almost no interference for 30 yr., within which period practically all the development of modern water power machinery has taken place. During the first half of this period, these characteristics covered commercial requirements which demanded the slowest speed wheel that could be made under high heads. While certain conditions, notably high heads, still demand tangential wheels, for about 15 or 20 yr. the requirements of commercial practice have frequently exceeded limitations imposed by conditions 2, 3 and 4,

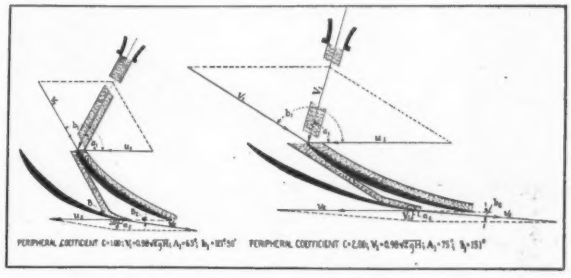


FIG. 1. CROSS FLOW VELOCITY DIAGRAMS

and to meet these new conditions, the new form of wheel proposed by the writer had departed from these three characteristics.

Contrary to the general impression, the modern impulse wheel is the slowest speed type of turbine known, although it utilizes the higher water velocities. This general impression of speed is based on the fact that it has found its field of application for such high heads that the actual rotative speed has usually exceeded that of the reaction types.

The peripheral coefficient of 50 per cent is usually presented as a fundamental consideration of all impulse wheel design, whereas it really should be presented as an extreme used to permit of securing the lowest possible bucket speed. The desirability of low speed in the buckets of these units has long since passed.

So far as water velocity is concerned, the impulse type of wheel would have the highest speed of any type of turbine, except those which may be classed within the so-called suction field. The water velocity in the usual reaction wheel seldom exceeds 50 to 75 per cent of the spouting velocity or the same percentage of that which holds in all impulse practice. The main reason for the low characteristic speed of impulse wheels is found in the fact that the whole periphery is utilized for developing power, whereas, the usual impulse wheel comes under the classification of partial turbine. The result is that in comparing on the basis of a certain capacity, the diameter of the impulse type becomes so large that its rotative speed is unduly reduced. This is further emphasized by the fact that the reaction wheel usually runs

* Abstract of paper presented at a joint meeting of the Milwaukee Engineering Societies, Milwaukee, Wis.

† Hydraulic engineer, Allis-Chalmers Mfg. Co.

with a coefficient of rim velocity, in the neighborhood of 60 to 90 per cent as contrasted to the 50 per cent for the present impulse type.

Speeds of tangential impulse wheels cannot be increased by reducing their diameter beyond a certain limit, because the bucket turns so abruptly out of the working path of the jet. The relationship between the characteristic speed of the tangential impulse wheel and its ratio of wheel to jet diameter, illustrates the approximate limitations of commercial practice. Exceeding the ratios indicated, simply means that there will be what is called racing water, with its inherent loss of efficiency.

Unit capacities have so grown that for a considerable period, possibly for the last 15 or 20 yr., strenuous efforts have been made to increase specific speeds of impulse

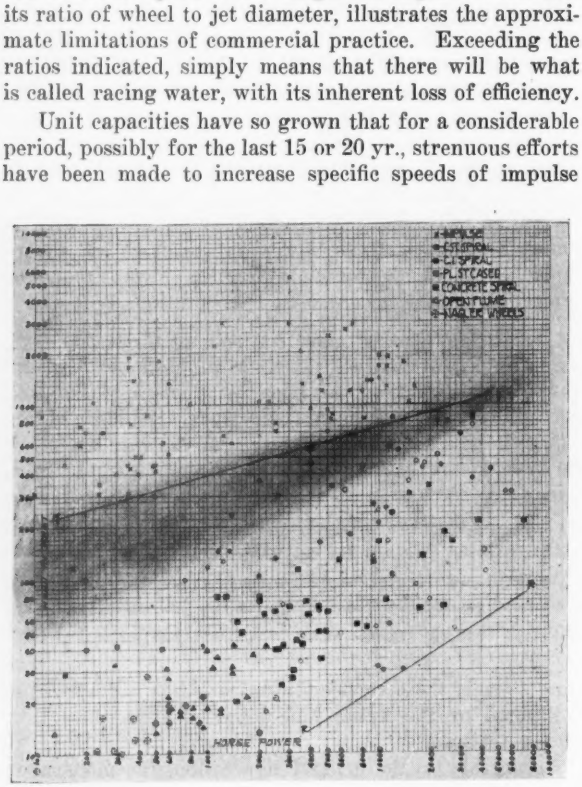


FIG. 2. HEAD CAPACITY PLOT OF THE ENTIRE FIELD OF HYDRAULIC TURBINES, INCLUDING PRACTICALLY ALL OF THE NOTEWORTHY INSTALLATIONS EVER MADE

Points above the line TT represent impulse units. The line RR represents practically the limit of reaction units either in size or capacity for moderate or low heads. The shade portion largely below the line TT represents a eld betwen the tangential impulse and the high head reaction fields which is at present disadvantageously dveloped by both of these types, and is the field to which the proposed type of Cross Flow Wheel is particularly adapted.

units. As is usual in such cases, human inertia has been such that the new need was not recognized, the result being that the art of impulse wheel design went through the same evolution as did the reaction type turbines, i.e., multiplicity of runners, nozzles, etc., without attacking the fundamental element of relative bucket velocity or direction of jets on the wheel to avoid interference. The orthodox 50 per cent velocity of bucket and tangential application of jet with its large consumption of wheel periphery, were and are still the dominant factors of the impulse units of even recent manufacture and of all engineering text books on the subject.

Speed in impulse wheel work is a function of the angle the jet makes with a tangent. If the jet angle is zero as in accepted present practice, the speed is the lowest that can be obtained without preventable loss. As the angle of the jet increases to 45 deg., the relative wheel velocity increases from 50 per cent to only 69 per cent of the jet velocity. From this point, however, the most radical increase is effected. For example, from a 59 per cent coefficient at 45 deg. the speed increases to 100 per cent at 61 deg. This feature combined with the obvious departure from the tangential flow of present practice led to the following designation of two classes of impulse wheels accordingly as the major component of the jet velocity is along or normal to the tangent.

Tangent impulse wheels, jets making an angle of less than 45 deg. with the tangent.

Buckets decidedly concave, curvature greater than 90 deg. Bucket inlet inclined backward.

Cross flow impulse wheels, jets making an angle greater than 45 deg. with the tangent.

Buckets flattened, curvature less than 90 deg. Bucket inlet inclined forward.

Aside from its advantage in speed, the Cross Flow Wheel automatically corrects one of the defects that contributed greatly to the failure of single flow impulse turbines, such as the Girard and other partial wheels. The backing of water resulting in its being dragged around with the wheel and ultimately discharged at wheel velocity, results from impact due to the large angle between the relative water path and the surface of the bucket at the point of impact. The slower the speed of the bucket the greater the curvature, consequently the greater the impact and "backing" loss.

With higher speeds the bucket becomes flatter and the backing loss with its poorer efficiency and greater tendency to pit is more and more reduced without resorting to the undesirable expedient of increasing the number of buckets. Inspection of the accompaying diagrams indicates how the angle of impact between the jet and bucket is reduced as the speed is increased and the bucket correspondingly flattened. The author believes that this principle can be utilized to eliminate or at least reduce the efficiency losses and pitting troubles experienced with the Girard types and with it there will be a return to radical and axial and even conical or mixed flow impulse wheels. In combination with nozzles designed to deliver circular jets with their higher efficiencies and more uniform distribution of velocities Cross Flow Wheels can be applied to a considerable portion of the field for which there is at present no design except the disadvantageous multiple runner or multiple nozzle types. For low heads and small powers or where efficiency may not be of the greater importance, the circular jet may be dispensed with and rectangular jets arranged partly to cover the wheel periphery or even solid annular jets may be utilized.

From an efficiency standpoint, the Cross Flow Wheel does have an inherent disadvantage. The relative velocity between jet (50 per cent of the spouting velocity) and bucket is the lowest in a tangential wheel and higher in the Cross Flow Types, for example for 100 per cent coefficient the relative velocity is practically twice what it is in a tangential wheel. This, of course, involves a greater friction loss but in actual practice this may be offset by reduction of windage and splash losses and particularly by the possibility of developing more power in a given working volume of space swept by the buckets than is possible with the tangential type.

Vertical impulse wheels have certain mechanical advantages when large capacities are considered, being similar to those which underlie the popularity and econo-

mies of the vertical reaction units and in addition incorporating the possibility of feasible mechanical arrangement of more jets than possible with horizontal types. Engineers experienced with impulse work, however, are familiar with the tremendous disturbances that exist even in horizontal wheels having but a single jet and can appreciate the condition that must exist when several jets are played on one wheel. When it is further considered that all the upwardly discharged water that falls or is spattered back into the path of the buckets must again leave the wheel at practically wheel velocity or half its own initial velocity, and that this represents a total loss, the desirability of getting the water positively and clearly away from the wheel is apparent. The Cross Flow design, embodying as it does the feature of single direction of flow through the wheel without backed water losses, lends itself admirably to this arrangement. This is particularly so as in extreme cases multiple or annular jets may be used without injurious interference, as each elemental jet uses such a relatively small portion of the periphery as contrasted to the tangential type where each jet needs for its working space a chord subtending a relatively large angle.

The significance of Fig. 2 lies in the comparatively undeveloped gap existing between the impulse and reaction types. This gap exists by reason of the difference between the highest impulse characteristic speed (about 5 ft. lb. units) and the lowest reaction characteristic speed (about 10). Even the multiplication of jets and nozzles incorporated in most of the larger capacity impulse units has failed to bring the two fields together.

The field of head and capacity now covered by impulse wheels of the tangential type needs extending only a limited amount. This extension is indicated roughly by the shaded section of Fig. 2, this section lying along and below the line TT, between the fields to which tangential impulse and reaction wheels are well adapted. Going beyond this neutral ground in a lower direction, involves competition with the reaction type runners that give economical generator speeds with lower water velocities and better efficiencies. It is to this intermediate field that the Cross Flow Impulse design is peculiarly adapted as with it characteristic speeds of 5 to 20 are readily obtainable with a single jet. With multiple or annular jets even higher speeds are possible, theoretically up to over 100. There will probably be no commercial demand for such extreme speeds using the Cross Flow principle as the reaction type covers this field satisfactorily and with more desirable water velocities. The greater simplicity of the impulse type may, however, make those high speed types work out advantageously with small units.

It is for lower heads and larger capacities that new designs are needed. While the elements of the machines themselves are not subjected to mechanical complication or hydraulic losses as serious as those which caused the multiple runner reaction turbine to be superseded by the single vertical arrangement, the general complications of water passages and governing mechanisms and possibilities of flow interference, are certainly such as to be expensive and undesirable.

ASH HAVING a fusing temperature of 2700 deg. F. will rarely give trouble if the fuel bed is properly handled. Clinker is formed by the mechanical adhesion of the particles of ash or by the fusion of the ash.

Steam Requirements of Radiators

SIMPLE METHOD FOR CALCULATING THE STEAM CONSUMPTION FOR VARIOUS CONDITIONS

IT IS OFTEN convenient, for purposes of steam distribution costs, to have at hand a method for calculating the steam condensed in various types of direct steam radiation. In some cases radiators are trapped so that test runs may be made by actually weighing the condensate; this, of course, is to be preferred to any method of calculation.

For preliminary estimates of steam consumption, or where tests cannot be readily made, the following method of calculation will prove satisfactory. For wrought iron pipe radiators and coils the pounds of steam per hour will equal $\frac{A \times K\,(T - t)}{H} \times 2$, in which

A = area of exposed surface in sq. ft.
K = a radiation constant, which for wrought iron may be taken as 2.0.
T = temperature, deg. F., of the steam in the radiator.
t = room temperature, deg. F.
H = total heat of steam above room temperature, B.t.u.

Assuming a room temperature of 70 deg. F. and a steam pressure of 5 lb. ga., it is found from steam tables that the temperature of the steam is 227 deg. F. and that H will be 1156 — (70 — 32), or 1118 B.t.u. Substituting these figures in the formula, it is found that

$$\text{Lb. of steam per hr.} = \frac{A \times 2.0\,(277 - 70)}{1118} \times 2$$
$$= A \times 0.56$$

For the ordinary cast iron radiator, the area of a given radiator may be approximately determined by the following rule:

$$\text{Area per section, sq. ft.} = \frac{B \times N}{20}, \text{ in which } B =$$

height of section in inches, and N = the number of columns per section. The average B.t.u. radiated per sq. ft. per degree difference is as follows:

Columns in C. I. radiator	B.t.u. per deg. per sq. ft. per hr. = K
1 col.	1.80
2 col.	1.70
3 col.	1.60

This applies particularly to 30 and 36-in. radiators.

Using the first formula given, and substituting in it the above values of K, and assuming the steam pressure and room temperature as before, it is found that

Lb. steam per hr. = 0.505 × A for a 1 col. C. I. radiator
Lb. steam per hr. = 0.477 × A for a 2 col. C. I. radiator
Lb. steam per hr. = 0.449 × A for a 3 col. C. I. radiator

Copper or aluminum coatings reduce the efficiency of a heater about 25 per cent below the results as given above, which are for the original metal surface. Snow-white enamel, white zinc paint and terra cotta enamel give a slightly greater efficiency than the original surface.

Power Plants in the Orient

A Review of Recent Power Developments in Japan. By S. Q. Hayes*

IN JAPAN the general trend of power plant design follows closely the practices of the American and European manufacturers that compete with local Japanese factories for the supply of equipment to important power consumers. During the last two years, a great deal of equipment has been ordered from American builders of apparatus to be used on Japan's 154,000-v. super-power system, so the latest developments

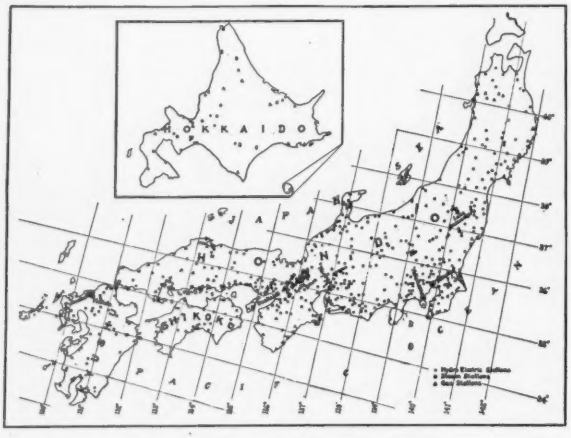


FIG. 1. POWER MAP OF JAPAN

are essentially American in many respects. As few people in America realize the extent of the power transmission work now in progress in Japan, some general information about the more important systems, as well as some details of apparatus recently supplied may be of interest.

The Japanese empire comprises a long chain of islands in the North Pacific, extending from 21 deg. 45 min. to 50 deg. 56 min. in a general direction from S.W. to N.E., roughly, about the same extent as from the City of Mexico to Quebec. The principal islands are the group comprising the main island of Hondo with Hokk Kardo at its northern tip, Kyushu near the southwestern tip, and Shikoku south of Hondo and east of Kyushu. The empire includes Taiwan or Formosa, Chosen or Korea, and Karafuto, the southern part of Saghalien, with many small islands, comprising a total area of 176,000 sq. mi. (about the area of Montana) and a population of about 70,000,000.

Central portions of the main island of Hondo are mountainous and the rainfall in Japan is plentiful, so that hydroelectric developments are extremely numerous. Figure 1 shows a map correct to 1917, locating the electrical developments; water power plants or substations supplied from water power plants being shown by circles, steam plants by squares.

As a good grade of coal is found on the island of Kyushu just off the southwestern tip of the main island, points on the main island that can readily be reached by boats from Kyushu, have steam plants, while most of the interior towns and villages throughout Japan, obtain their electrical current from hydraulic plants. The principal electrical developments are on the main island, centering at Tokyo and Yokohama where 50-cycle current is employed, and Osaka, Kobe, Kyoto and Nagoya where 60 cycle current is used.

In the central position of Hondo the Japanese Alps rise to an elevation of 10,000 ft. or more and are usually within 50 to 75 mi. of the coast so that the rivers rising on the mountains have a considerable drop in a short distance.

In all of Japan approximately 10,000,000 kw. of hydroelectric power can be developed of which 7,000,000 kw. is on the main island of Hondo. Of this amount 5,500,000 is economically applicable and the remainder is not. The rivers of the central portion of Hondo have a combined capacity of about four and a half million kw. most of it within a radius of 75 mi. from Mount Ontake, and the important markets of Tokyo and Yokohama to the east and Nagoya, Osaka, Kobe and Kyoto to the west are within a radius of 150 mi. from this same central mountain.

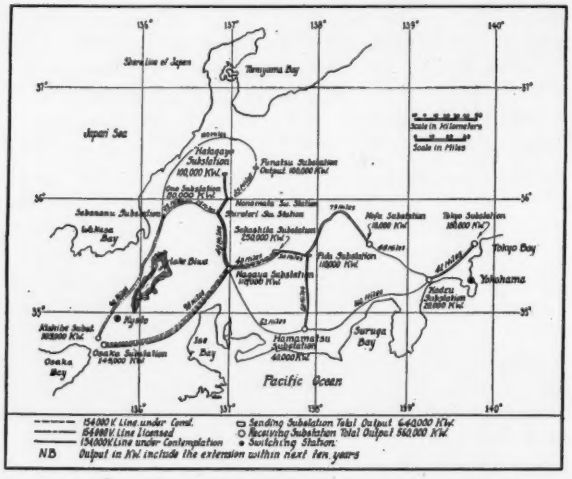


FIG. 2. SKELETON DIAGRAM OF DAIDO SYSTEM

For the transmission of large amounts of power and tying together the scattered plants of large systems, 154,000 v. has been determined on as the voltage for the generating stations.

Figure 2 shows the principal, present and proposed lines of the Daido Company including those now under construction, those for which license has been obtained, and those planned for future development. The total generating station output including extensions contemplated within the next 10 yr. amounts to 640,000 kw.

These lines of the Daido Company constitute a superpower system of considerable magnitude, as the distance between Tokyo and Osaka, the two extremities of the system, is about 330 mi. along the routes selected for the power lines. When these Daido lines and other 154-kv. lines now contemplated are completed, there will be between 3000 and 5000 mi. of 3 phase, 154-kv. circuits in Japan. As soon as enough power generating stations have been completed to supply the power demands of the Nagoya and Osaka districts, the Momo-

*General Engneering Dept., Westnghouse Electric & Mfg. Co.

yama station of the Daido Company will be changed over to 50 cycles and will be used with other plants for transmitting power to the Tokyo district.

Figure 3 shows one of the two 15,000-kv.a., 6600-v. vertical shaft waterwheel generators furnished by the Westinghouse Co. for the Momoyama station. This machine will operate at 300 r.p.m. for 60-cycle service, or at 250 r.p.m. for 50-cycle service. For 50-cycle service, the machine windings will be in straight star, while for 60-cycle service at the higher speed, they will be in interconnected star. This transfer from straight star to interconnected star, permits the generator to deliver essentially the same voltage with the same field charge at either of the two speeds.

FIG. 3. ONE OF THE 15,000 KV.A. GENERATORS FOR MOMOYAMA

Fifteen thousand kv.a. synchronous phase modifiers have been supplied both to the Daido Power Co. and the Tokyo Electric Light Co. These units are provided with direct connected exciters and automatic voltage regulating equipment, for the purpose of maintaining, as far as possible, constant voltage on the secondary distribution at the receiving station.

Each machine is provided with a motor driven oil pump and an automatic starting arrangement that first energizes the motor of the oil pump. When the oil pressure reaches the proper amount to float the shaft in the bearings, a contact on the oil pressure gage closes the starting breaker and the modifier starts up as an induction motor, with its field short-circuited through the direct connected exciter. Until synchronous speed is reached pulsating current passes between the modifier field and exciter armature, and the current transformer in that circuit acts on an a.c. relay. When synchronous speed is reached, pulsating current ceases, the relay then functions to trip out the starting breaker and connects in the running breaker.

In competition with the Daido Company and in connection with the Ujigawa Electric Company, the Nippon Power Company also feeds into Osaka. The plants now being constructed comprise the transformer station at Sasazu, the generating station at Seto, several switching stations and the receiving station at Osaka. A new steam installation at Osaka is also on order with 20,000-kw. turbo-generators and transformers for supplying the 55,000-v. system.

At Sasazu there are two incoming lines at 60 kv. with transformer banks stepping up from 60 kv. delta to 154 kv. star. Transmission lines at 154 kv. extend to Osaka.

In Osaka and vicinity there are about a dozen important substations, each with one or two synchronous phase modifiers and an installed transformer capacity

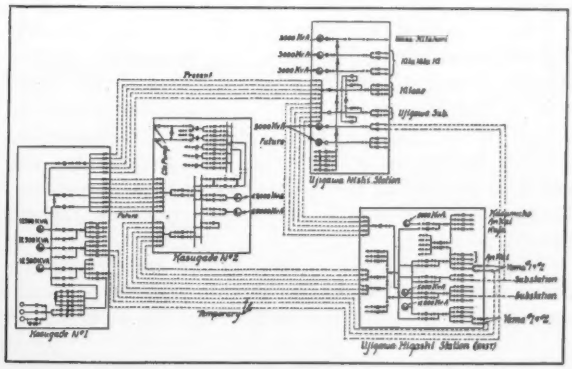


FIG. 4. MAIN INTERCONNECTIONS OF THE STEAM PLANTS OF THE OSAKA ELECTRIC CO.

of about 75,000-kv.a. The Ujigawa system is used primarily for power distribution and special permission has to be received by it to allow for supplying current for lighting purposes, as the Osaka Electric Light Co. takes care of the lighting requirements of Osaka and vicinity.

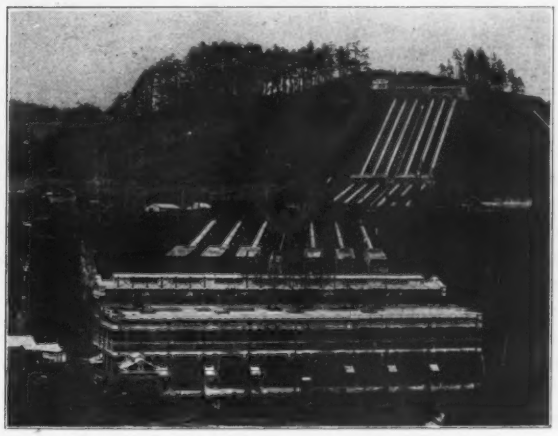


FIG. 5. A VIEW OF THE INAWASHIRO STATION

Figure 4 shows the main interconnections of the steam plants of the Osaka Electric Company. At the Kasugade No. 1 station, there are three 12,500-kv.a. turbo generators supplying power in bulk to the Ajigawa West Station; the Ajigawa East Station and tie circuits are provided with the Kasugade No. 2 station now under construction.

This Kasugade No. 2 station is provided with two 25,000-kv.a. 11,000-v. Westinghouse turbo generators, feeding through oil circuit breakers to a double set of bus bars. These busses supply three group feeders, one for the local service, one connecting to Kasugade No. 1, and one connecting to Ajigawa East Station.

In the Ajigawa West Station there are five 3000-kv.a. Westinghouse turbo-generators connected to a sectionalized bus, while in the Ajigawa East Station there are

two 5000-kv.a. Westinghouse turbos and one 12,500-kv.a. of another make.

Most of the power for the Tokyo district is developed and distributed by the Tokyo Electric Light Co. or one of its subsidiaries. The latest developments are those connected with the delivery of power to the new Kameido Terminal Station in Tokyo.

One of the sources of power for the Tokyo Electric Light Company is the system of the Inawashiro Hydro-Electric Power Company which delivers about 40,000 kv.a. to Tokyo over its 115-kv. transmission lines that extend for a distance of about 145 mi. This system was the first in Japan to operate at more than 77 kv. and has been a training school for many of the prominent Japanese engineers who are now responsible for the 154-kv. power systems.

Figure 5 shows the exterior of the first Inawashiro power house on the down stream side with the penstocks coming down the hill from the forebay. These penstocks

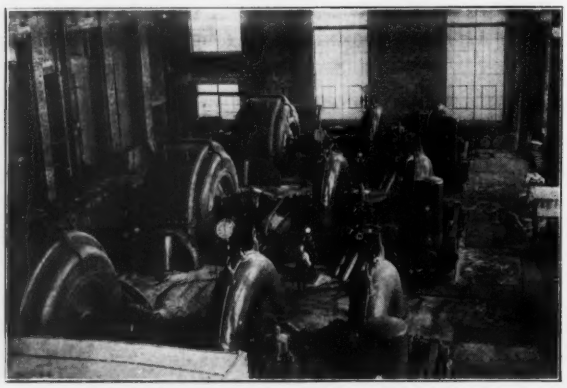


FIG. 6. INTERIOR VIEW OF THE INAWASHIRO PLANT

are held in massive, concrete anchorages wherever there is a change in the slope. The overflow from the forebay is seen to the right of the penstocks. The line supplying power to the head-gate house as well as the steps and path leading from the power plant to the forebay, are at the left of the penstocks. The heads over the ventilating ducts supplying cold air for the generators, can be seen between the lower windows.

Each penstock from the forebay passes under the transformer and switch section of the plant under the generator, and is then connected to the double flow horizontal shaft Francis type waterwheel. The station contains six 7700 kv.a. waterwheel generators, twelve 4400-kv.a. single phase transformers used in four groups stepping up from 6600 v. to 115,000 v. This was the first installation in Japan to operate at more than 77,000 v. and has been running at 115,000 v. for the last 8 yr. The transformers are located in individual masonry cells, and are arranged with wheels on the rails so that they can be rolled out into the generator room and handled by the crane.

At the time when this installation was put in, the Japanese Government would not countenance the use of outdoor equipment for an important installation of this kind. During the last year or two, however, over 400,000 kv.a. in outdoor transformers for 154 kv. service have been ordered from the Westinghouse Co. for various Japanese installations.

Figure 6 shows the interior of the Inawashiro installation during construction. The plant contains six 10,000-hp. horizontal shaft water wheels made by Voitb of Germany running at 375 r.p.m. under a head of 350 ft. There are also four 300-hp. impulse type water wheels running at 600 r.p.m. for driving the exciters.

Painting Steel Stacks

IN MOST instances, the outward appearance of steel stacks is anything but complimentary to those responsible for their upkeep. There are, of course, steel stacks used for industrial furnaces which are extremely difficult to maintain, due to the presence of highly concentrated acid fumes and the discharge of waste gases at extremely high temperatures.

Steel stacks used to carry away the waste gases from boiler furnaces can and should be properly painted at such intervals as may be required. Such stacks are seldom subjected to extreme conditions of exterior acid corrosion, and with proper boiler operation they will not be subjected to high temperature. It is not contended that exterior corrosion is as important as is that which takes place internally, but rather that the urgency of steel stack painting is in great measure a question of pride.

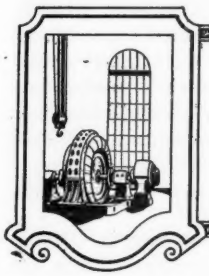
Certain fundamentals must be followed if a satisfactory paint job is to be obtained. Steel stacks should not be painted when wet, nor during damp or freezing weather. The two latter operations apply to that portion of the stack exposed directly to the weather. The temperature of the stack should in no case be above 300 deg. F. at the time the paint is applied, a temperature of 200 deg. F. would be considered about right.

Paint applied over dirt, rust and loose paint will not give satisfaction, therefore scrapers and wire brushes should be used to obtain a good clean surface to which the new paint may be applied. The galvanized surfaces should either be etched with a 20 per cent acetic acid solution or allowed to weather for from 6 to 9 mo. after which a first coat of oil paint mixed with 15 per cent naptha may be applied. All recesses which may retain water should be filled with thick paint or some weather-proof cement before the final painting.

It is essential that the paint be evenly spread on and thoroughly rubbed out to exclude all air from beneath its surface. A stiff round brush will probably be the best for this purpose. Paint should not be sprayed on with air because by so doing air is trapped beneath the surface and the durability of the paint is impaired.

During cold weather, tar and asphalt paints may be heated up to 150 deg. F. to facilitate application. Stock paints should not be thinned with gasoline or benzine. In extreme cases, a small percentage of turpentine may be used for the purpose of thinning.

Paints used for high heat resistance are mixed with a special oil; therefore, when arching, a statement should be made as to the maximum temperature to which the surface will be heated. Coal tar paint may be used for surfaces where the temperature does not exceed 450 deg. F. Once used, however, it is necessary to clean off the old coat before repainting. Graphite paint will withstand high temperatures and it is comparatively easy to apply, which facilitates a thorough rubbing out.



ELECTRICAL MACHINERY FOR LIGHT AND POWER

Protective Features of Current Limiting Reactors

CURRENT LIMITING REACTORS ARE TO BE REGARDED AS INSURANCE AGAINST DISASTROUS EFFECTS OF SHORT CIRCUIT CURRENTS. BY C. L. KNOTTS*

IN THE recent rapid growth of alternating current systems and the enormous concentrations of power in generating systems, considerable attention has had to be given to the limiting of current which may flow under various conditions of short circuit. There are three important reasons why this has been necessary. In the first place, certain pieces of apparatus such as generators and transformers may require protection from the mechanical stresses which accompany short circuit currents. In such cases the reactor is usually connected directly in the leads of the apparatus. In the second place, it may seem advisable to confine the drop in voltage which accompanies a short on the system to the particular part affected. In this case, reactors are usually installed between the various generator units in a station or between the various stations of a system. This class of reactors is usually referred to as bus sectionalizing reactors. In the third place, it is often necessary to limit the current which may flow in distribution circuits to values which will not cause injurious heating in the conductors. It frequently happens that all of the above types, namely, generator, bus and feeder reactors, are used on the same system. In all cases, however, it is desirable to make a thorough study of the system both present and future to determine which type of reactor is best suited to accomplish the desired results with the minimum outlay of capital.

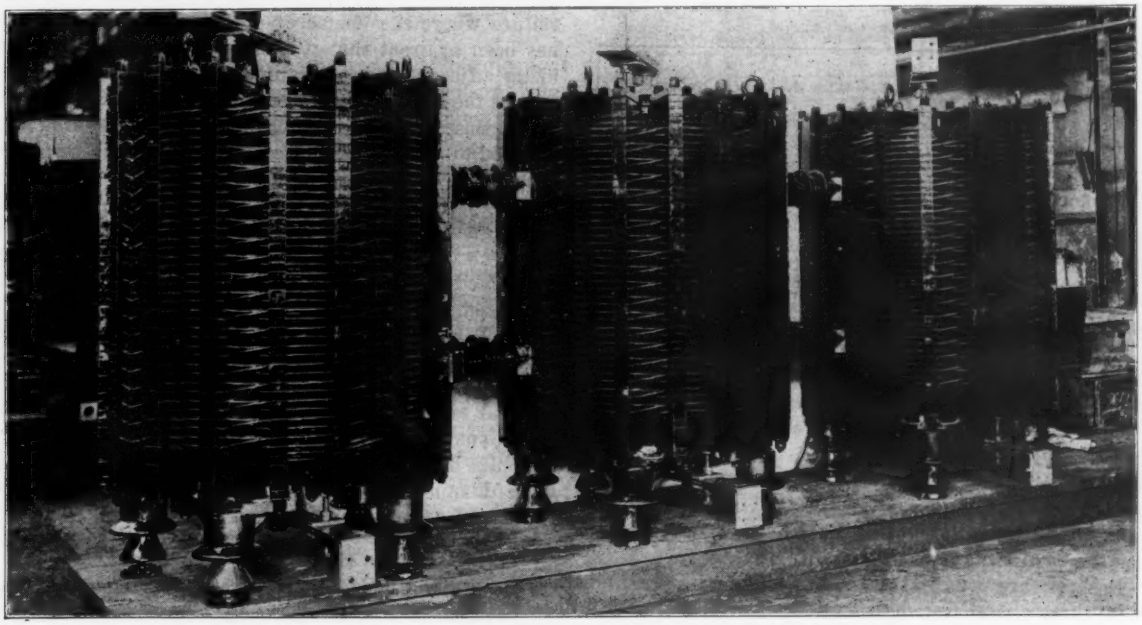


FIG. 1. TYPICAL BUS REACTOR, 417 KV.A., SINGLE PHASE, 25 CYCLE, 2190 AMP., 5 PER CENT ON A 6600-V., 3-PHASE CIRCUIT

Reactors are capable of limiting short circuit current because of their ability to set up a counter voltage directly proportional to the current passing through them. This counter voltage expressed in volts is directly proportional to the frequency of the current and the inductance of the circuit. The inductance is that characteristic of the circuit which tends to oppose any change of current which may occur in the circuit. It depends upon the number of turns and upon the physical dimensions of the windings themselves. Inductance is expressed in henrys while the reactance is expressed in ohms. For instance, reactance ohms are expressed by the formula 6.283 fL, where "f" represents fre-

*Transformer Engineering Dept., Westinghouse Electric & Mfg. Co.

quency in cycles per second and "L" inductance in henrys. Reactance volts are expressed by 6.283 fLI, where "I" represents current in amperes. With normal current flowing in a circuit, therefore, there will be a certain definite drop in voltage across the reactor which is vectorially at right angles to the current. Under normal conditions of operation, this drop in voltage across the reactor serves only to decrease the power factor (that is to increase the wattless kv.a. by an amount equal to its own rating) of the circuit slightly and to increase the loss by a very small amount. For example, a 6600-kv.a., 13,200-v. feeder circuit in which there is installed a 5 per cent reactor has a power factor of 80 per cent. Before the installation of the reactor the power factor was approximately 82½ per cent.

Under short circuit conditions, however, with only the reactor remaining in the circuit the entire phase voltage must appear across the reactor. Since the reactor has a low power factor, that is, an extremely low resistance in proportion to its reactance, the voltage drop across the reactor will be absorbed almost entirely by means of the reactance. This means that if under

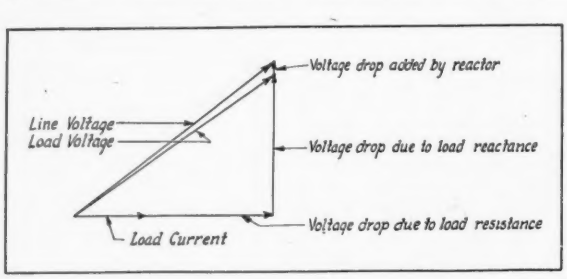


FIG. 2. VECTOR DIAGRAM SHOWING EFFECT OF REACTOR IN 80 PER CENT POWER FACTOR CIRCUIT

normal conditions the reactive drop across the coil is 5 per cent of phase voltages, the short circuit current will be $\frac{100}{5}$ or approximately 20 times normal. This applies to all coils whose ohms reactance remain constant over the required range in current.

Reactors are usually installed in series with the line. On a three-phase system, therefore, the reactors will carry line current and their voltage will be figured as a percentage of voltage to neutral.

Current limiting reactors are always made with air cores when short circuit currents are to be in excess of approximately four times normal. It is uneconomical to work iron at sufficiently low flux density that the voltage will be directly proportional to current for a greater number of times full load current.

The function of the reactor is to limit the current in the circuit to a predetermined safe value until the circuit may be opened. This is frequently done by automatically operated oil circuit breakers in a fraction of a second, but it may require a matter of seconds due to selective relay operation of breakers. In any case, the reactor must be designed to limit the current in the circuit to a value which will not damage any piece of apparatus connected to the circuit. Under normal operation, there are no benefits to be derived from the reactor and, since its benefits are to be derived only from its proper functioning under the most unusual and abnormal conditions, the reactor should be absolutely reliable. It should be looked upon as a protective device, and, as such, it should possess a factor of safety far in excess of other apparatus such as generators, transformers, etc. With this idea in mind special emphasis has been placed upon the following fundamental considerations of design by the manufacturer.

Mechanical Strength

It was early realized that unusual magnetic forces would be met in current limiting reactors due to the large and unconfined magnetic field existing at times of short circuit. In some of the earlier designs, however, the magnitude of these forces was underestimated. These forces when analyzed are found to be of two kinds, namely, internal and external.

Internal forces may be subdivided into two kinds, namely, those tending to enlarge the diameter of the coil and those tending to shorten the axial length of the coil. The former are of little importance as the resulting stresses are well within the tensile strength of the copper. The latter, however, have been known to cause failure where the length of the unsupported conductor has been so great that it was possible for the forces to bring adjacent conductors in contact. These forces, as well as the others named, are subject to accurate calculation. Based upon operating experience extending over a period of years, as well as upon calculations, the proper spacing between supports on reactors has been determined by the manufacturer.

Magnetic forces existing between reactors are found to vary with the separation center to center. For ordinary feeder reactors which are bolted to the floor of their compartments, a horizontal separation center to center equal to 15 per cent of the outside coil diameter will not require external bracing for currents which bear a three-phase relation. For a similar condition, a vertical separation equal to 175 per cent of the outside coil diameter will not require external bracing. For currents between adjacent reactors in the same phase, these distances should be increasd 20 per cent to avoid the use of external bracing.

Voltage Stresses

Quite abnormal voltage stresses are likely to be set up between end turns of reactors at times of disturbance on the system. Abnormal voltages are due, in the main, to high frequency line disturbances or to switching operations. To insure the safe operation of the coil, it has been found necessary to provide additional space between end turns. Under short circuit conditions too, the reactor must withstand phase voltage at normal frequency in addition to possible abnormal high frequency voltages. Present designs are made so as to withstand approximately seven times phase voltage at high frequency between terminals. They will also withstand the same test at normal frequency to ground. While these values may seem relatively high, it is believed that they are entirely in line with the degree of reliability required of the apparatus.

Thermal Requirements

Heating of the conductors in reactors is of primary importance. As in the case of mechanical stresses and voltage stresses, the conditions of heating are worst under conditions of short circuit. At such times, losses

are generated at a rate far in excess of the normal. All of the loss in excess of the normal loss, neglecting cooling by radiation and convection, goes to raise the temperature of the copper. This rise in temperature is at the rate of one deg. C. per sec. for each 180 watts per lb. loss in the copper. Hence a 4 per cent reactance coil operating with rated current at 10 w. per lb. will generate loss on short circuit (assuming supply voltage maintained) at the rate of $\left(\frac{100}{4}\right)^2 \times 10 = 6250$ w. per lb.

This loss will cause a rise in copper temperature per second of $\frac{6250}{180} = 35$ deg. C. approximately. This rise must be assumed as following continuous rated load conditions, and hence for periods of 5 sec. or more this condition would produce very high temperature. Above 250 deg. C. copper loses tensile strength very rapidly and, inasmuch as maximum stress on the top and bottom conductors of the coil usually occurs simultaneously with these high temperatures, it is important that the short circuit temperature be limited to a conservative value such as 250 deg. C.

Air core reactors are usually wound of bare copper cable making use of non-fibrous material supports. They are, therefore, capable of operating under rated current conditions at temperatures as high as 140 deg. C. with entire safety. As indicated above, low percentage reactors, such as 3 per cent coils, must of necessity be designed to operate at low copper densities at rated current in order to limit the rise under short circuit; however, it seldom occurs that coils are built for such high operating temperatures for economical reasons. High operating temperature is usually accompanied by high loss. According to the usual method of evaluating losses, the customer is able to demonstrate an actual saving by buying relatively low loss coils.

For example, assume power costing a half cent per kilowatt hour and a load factor which will give approximately full load loss one-third of the time. Then for each kilowatt saved the customer will save $\frac{1}{3} \times \$0.005 \times 24 \times 365 = \$14.60$.

This amount capitalized at 15 per cent will represent an investment of approximately $100; that is to say, the customer could afford to pay under the above assumption $100 more for each kilowatt less loss in the reactors offered him.

Summary

Current limiting reactors are to be regarded as insurance against the disastrous effects of short circuit currents. They are properly classed as a protective device and as such are provided with an unusually large factor of safety mechanically, electrically and thermally.

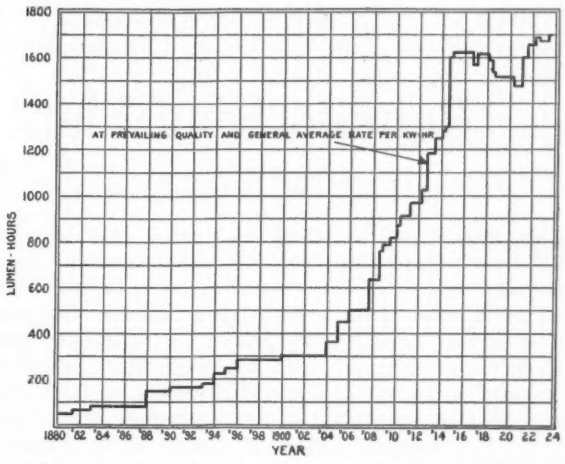
Disconnecting switches are being purchased by many companies, with a higher voltage rating than the voltage on which they are to be used. This is especially true for outdoor installations up to 70,000 v. This extra rating varies from 100 per cent for the lower voltage switches to 15 per cent for those to be used on higher voltages. The use of lock type switches is increasing very rapidly both for indoor and outdoor use, especially on systems of large capacity. Some companies are even replacing their old disconnecting switches with the lock type.

Quality of Incandescent Lamps

In a paper presented at the annual convention of the American Institute of Electrical Engineers, J. W. Howell and Henry Schroeder described the improvements which have been made in incandescent electric lamps since they first became commercially available.

Quality is the term used by incandescent lamp engineers in connection with the relative excellence of the lamps. The two main factors which determine quality are efficiency and life. With a given quality, these two factors bear a reciprocal relation to each other; that is, the life of the lamp can be increased, but at a sacrifice of efficiency, and vice versa.

In the new specifications for incandescent lamps, quality is determined in terms of life to burnout at a specified mean efficiency. Formerly it was measured by the life to 80 per cent of initial value. The new tests, therefore, conform more nearly to the actual practice in the use of tungsten filament lamps, as many of these lamps are above 80 per cent at time of burnout.



LUMEN HOURS FOR ONE CENT AT APPROXIMATE GENERAL AVERAGE RATES FOR CURRENT 1880-1923

Data on carbon lamps in the paper are based on a life exponent originally determined by Mr. Howell, one of the authors. Curves showing the relation between life, efficiency and candle power was given by him in a paper presented before the institute on April 10, 1888. Practically the same life-candle power relation has been found to apply to the GEM, tantalum and tungsten filament lamps. Nowadays the exponent used is that applying to the life-efficiency relation and is different for each kind of filament as they have different candle power-efficiency relations. All data are based on commercial ratings and guarantees.

Since their commercial introduction in 1907, the quality of tungsten filament lamps has greatly improved, as is shown by the fact that the 40-watt vacuum lamp is now over eight times as good as then.

There is a difference in the present relative quality of the various sizes of tungsten filament lamps. The 10-watt vacuum lamp, if operated at 10 mean lumens per watt, would live 190 hr., and the 1000-watt gas-filled lamp 35,000 hr. The lives of the other sizes of lamps at this efficiency is between these two extremes.

There has been an enormous improvement since Edison's first commercial carbon lamp of 1880. It is estimated that if the present 40-watt tungsten filament lamp were made for the same mean efficiency as the 1880 lamp, the tungsten filament lamp should have a life of over 150,000 yr. And this does not include the enormous improvement in the larger sizes of lamps due to Dr. Langmuir's invention of the gas-filled lamp. Owing to these enormous differences, the other term of quality measurement indicating the mean efficiency for a given life is therefore used to show the improvements since 1880.

It is estimated that in 1880 about 50 lumen-hours of light were obtained for one cent, covering the cost of current and lamp renewals. The amount now obtainable is much greater, due to lamp improvements, reduction in their prices and reduction in rates for current. With the present 40-watt tungsten filament lamps and with current at the present approximate general average rate of 4½ cents per kw.-hr., 1700 lumen-hours can he had for one cent. It is impossible to show what part of this actual increase is due to lamp improvements except to indicate what would have been obtainable with one factor without the other. Thus had there been no rate reduction, 432 lumen-hours would now be had due to actual lamp improvements. Without the lamp improvements, 190 lumen-hours would now be had due to the reduction in the general average rate. To indicate the gain due to Dr. Langmuir's invention of the gas-filled lamp, in which the high wattage sizes are the most efficient, 3820 lumen-hours can be had with the 1000-watt lamp at 4½ cents per kw.-hr.

About half a billion dollars were spent in the United States in 1922 for current used for lighting. If the same amount of light were produced by the original 1880 bamboo carbon lamps, the cost would have been increased 3½ billion dollars, requiring about 50 billion extra tons of coal, equal to about 10 per cent of the total production in the United States.

Remotorizing Plant Raises Power Factor

PART II. EFFECT OF STATIC CONDENSER AND METHODS OF DETERMINING ITS CAPACITY. BY O. H. HENSCHEL

ON PAGES 883 to 887 of the Sept. 1, 1923, issue of Power Plant Engineering was published an extensive account of the effect on the power factor of an industrial plant electric system and of the use of proper sizes and types of electric motors in a pressed steel plant. As portrayed in this article the power factor of this particular installation was increased over 100 per cent by the application of proper motors and as the power factor obtained was not as high as was possible of attainment, the necessity of the installation of some form of correcting device was obvious. Because of its low initial cost, maintenance and electrical lines and the fact that no advantageous use could be found for a synchronous motor it was decided to install a static condenser.

ADVANTAGE OF HIGHER POWER FACTOR

Under the existing contract with the power company a demand charge of $2 for each of the first 200 kw. and $1.50 for each kilowatt in excess of 200 is made and in addition to this and as explained in the above mentioned article "the maximum demand upon which a monthly charge for power service is based shall not be less than 75 per cent of the highest billed demand during the period of 12 months ended with the current month. Under these conditions, however, it was found that no savings resulted by raising the power factor in excess of about 60 per cent the approximate average value reached upon completion of remotorization of the plant.

This matter was then taken up with and explained to the officials of the power company who readily made favorable concessions in the way of making a demand charge of $2 per kilowatt on the first 150 kw. demand and $1.50 on each kilowatt in excess of 150 and also to make "the maximum demand upon which a monthly charge for power service is based shall not be less than 75 per cent of the highest metered demand ascertained during the period of 12 months ended with the current month," these concessions, however, only to be made upon the condition that a correction device of approved type such a static condenser be installed.

To determine approximately the savings to be realized by the use of such a static condenser the schedule in

(A)	(B) M.D.	(C) B.D. 60% P.F.	(D) B.D. 100% P.F.	(E) Demand Charge 60% P. F.	(F) Demand Charge 100% P. F.	(G) Savings
Dec. 21	150	200	120	$400.00	$300.00	$ 100.00
Jan. 22	161	214	128	421.00	300.00	121.00
Feb.	196	261	156	491.00	309.00	182.00
Mar.	184	245	147	468.00	300.00	168.00
Apr.	161	214	147	421.00	300.00	121.00
May	168	224	147	436.00	300.00	136.00
June	177	236	147	454.00	300.00	154.00
July	190	253	152	480.00	303.00	177.00
Aug.	194	258	156	487.00	307.50	179.50
Sept.	216	288	172	532.00	333.00	199.00
Oct.	181	241	162	460.00	318.00	142.00
Nov.						
Dec.	159	212	162	418.00	318.00	100.00
Jan. 23	159	212	162	418.00	318.00	100.00
Feb.	164	131	162	400.00	318.00	118.00
				Savings for 14 Mo.		1997.50
				Average savings per Month		142.68

FIG. 1. SAVINGS IN POWER COSTS POSSIBLE BY USE OF A 60-KV.A. STATIC CONDENSER

Fig. 1 was prepared. Nineteen twenty-two being a year fairly representative of average activity of the plant the period from and including December, 1921, to February, 1923, was employed for this purpose. Column (B) indicates the actual metered demand, column (C) the billed demand under 60 per cent power factor, column (D) the billed demand under 100 per cent power factor, column (E) the demand charge under 60 per cent power factor, column (F) the demand charge under 100 per cent power factor and column (G) the accrued savings. These as shown, and based upon the 1922 demands, amount to $1997.50 for the 14-month period or about an average of $142.68 per month. For a 12-month period this would be approximately $1712.16.

Taking the month of December, 1921, as an example the demand charges were determined as follows: In determining the billed demand the standard power factor of 80 per cent is accepted so that with a metered demand the billed demand is equal to the quotient obtained by dividing the product of 150 and 80 by 60 (the assumed power factor) or 200. The demand charge is then as indicated in column (E) equal to 200 times \$2 or \$400; under 100 per cent power factor the demand (billed) is equal to 120 kw. but as 150 kw. must be paid for the actual charge is 150 times \$2, or \$300, thus resulting in a saving of \$100.

Demand Charge Charts

For reference in determining the billed demand and therefore the demand charges under various values of metered demands and power factors the chart, Fig. 2, is convenient. Assume for example as shown by dotted line A D G that the metered demand is 175 and the

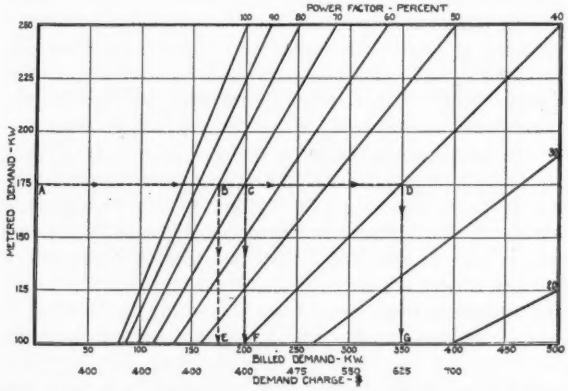


FIG. 2. CHART FOR DETERMINING THE DEMAND CHARGES UNDER VARIOUS VALUES OF METERED DEMANDS AND POWER FACTOR

power factor is 40 per cent; the billed demand is then as indicated at point G equal to 350 kw. while the demand charge is \$625. Had the power factor been 70 per cent, however, instead of 40 per cent the billed demand would have been 200 kw. with a demand charge of \$400.

Under the terms of the existing contract whereby at least the first 200 kw. of demand must be paid for at the rate of \$2 each further increase of power factor would be of no benefit, for as indicated by B E, although the billed demand is reduced to 175 kw. the demand charge still remains at \$400.

A careful study of this chart will, however, reveal the effect upon the demand charge of reducing the fixed demand from 200 to 150 kw. as explained above. With such change and with a metered demand of 175 kw. the power factor can advantageously be raised to approximately 93 per cent. Further increase of power factor would, however, be of no benefit as is quite obvious.

Determining Size of Condenser Required

Although the weekly power factor enjoyed by this installation is now frequently somewhat in excess of 70 per cent it was deemed advisable in considering the problem of determining the size of static condenser required to work within the limits of from 65 to 90 per cent power factor; that is, to determine the kilovolt amperage capacity of condenser necessary to raise the power factor from 65 to 90 per cent.

Assuming a load of 175 kw. the approximate average for the months enumerated in the schedule, Fig. 1, with a present power factor of 65 per cent and a desired power factor of 90 per cent the size of condenser required can be determined as follows:

A 175-kw. load at 65 per cent is equal to 175 divided by 0.65 or 269.2 kv.a. apparent load which has a wattless component lagging of $\sqrt{269.2^2 - 175^2}$ or 204.5 kv.a.

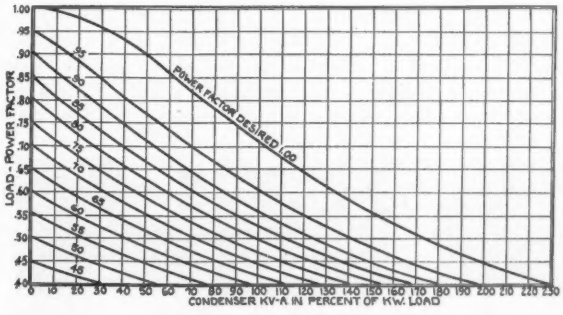


FIG. 3. CHART FOR USE IN DETERMINING STATIC CONDENSER CAPACITY

A 175-kw. load at 0.9 is equal to 175 divided by 0.9 or 194.4 kv.a. apparent load which may be expected when the condition of 90 per cent power factor is realized. This has a wattless component lagging of $\sqrt{194.4^2 - 175^2}$ or 84.7 kv.a. The difference, 204.5 minus 84.7, or 119.8, or let us say 120 are the leading kilovolt amperes that will be necessary to raise the power factor of the load to 90 per cent.

From this it would appear as though a 120 kv.a. condenser was required. Such, however, is obviously not the case when it is remembered that the condenser can well be kept on the line 24 hr. out of each day with practically no cost for energy and that while the maximum demand is 175 kw. the average load is much less than this value. Accordingly with the plant normally operating only 9 hr. per day but with the condenser on 24 hr. it is estimated a 60 kv.a. capacity unit will be of ample size at least to insure a monthly power factor of no less than 95 per cent.

For use in determining the capacity of a static condenser in kilovolt amperes in per cent of the kilowatt load and knowing the existing power factor and that desired the curves illustrated in Fig. 3 may be employed. Applying this chart to our specific problem in which the existing power factor is 65 per cent and the desired power factor is 90 per cent, we find that the condenser should have a kilovolt-ampere capacity of about 78 per cent of the load which was assumed as 175 kw. This would be, as before determined, approximately 120 kv.a.

During recent years there has been a marked tendency toward a reduction in the number of ducts in important conduit runs. Some companies have decided to limit the number of ducts to twelve and there are cases where eight is the maximum allowed. This has been brought about by the heavy loading of cables and the resultant overheating if there are too many cables in one duct run.

Air-Lift Pumping by Diesel Compressor

CITY OF FOND DU LAC HAS REDUCED COST OF PUMPING BY ADDITION OF DIESEL COMPRESSOR UNIT TO WATER PLANT. BY P. M. THAYER

WHEN it became necessary last year to increase the capacity of the city of Fond du Lac pumping plant, a number of methods were considered; but it was finally decided to take advantage of the low operating cost of the Diesel engine and a compressor unit of this type was therefore installed. The operating costs so far have more than justified the choice. Up to the present time, the Diesel compressor unit has saved from $30 to $35 worth of coal a day with the expenditure of about $11 worth of oil, or a yearly saving of about $7000. Contrary to the belief of a great many people, it was not necessary to increase the plant personnel in any way;

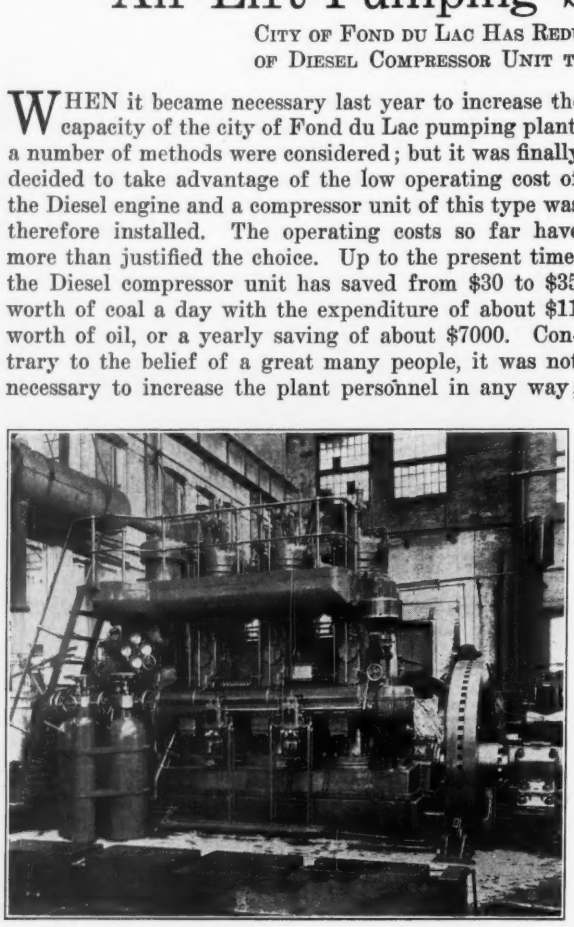


FIG. 1. THREE POWER CYLINDERS AND A COMPRESSOR CYLINDER MAKE UP THE COMBINATION UNIT

the same crew that had been running the steam plant took over the operation of the Diesel engine and experienced no difficulty in handling it from the start.

This Diesel driven compressor unit has a capacity of 1700 cu. ft. of free air per minute compressed to 80 lb. per sq. in. The compressor itself is a rather unique design, being of the vertical differential piston type. The low pressure cylinder is at the top, the high pressure cylinder being between the body of the piston and the large diameter of the cylinder. The accompanying cross-sectional view, Fig. 2, shows this arrangement. It also shows the way the intercooler is built into the cylinder casting. This arrangement of cylinder and intercooler eliminates tortuous connecting passages and all losses due to that cause. The intercooler itself is of the counterflow type with several baffles in both the air and water passages which cause both the air and water to flow through the intercooler several times in opposite directions. The counterflow action effectively cools the air and makes its temperature at the high pressure suction valve nearly equal to that of the ingoing cooling water.

Water is obtained from six wells although there are ten wells belonging to the city. Originally the pumps drew the water directly from the wells and forced it through the mains by direct pressure. As the level of the wells dropped, it became necessary to install a reservoir for supplying the pumps. The first arrangement was to use motor driven deep well pumps; but on account of the excessive repair cost of these pumps, they were abandoned and an air lift system was installed.

At present the installation consists of a combination steam and Diesel engine plant. The pumping from the reservoir into the mains is done by two 3,000,000-gal. Holly steam pumping engines which have been in service over 35 yr. There is also one 2,500,000-gal. Prescott triple expansion duplex plunger pump which acts as an emergency pump. For supplying compressed air for the air lift, there is one Ingersoll-Rand steam driven compressor of 2000 cu. ft. capacity and one Nordberg Diesel-driven compressor of 1700 cu. ft. capacity. Steam is supplied at 110 lb. pressure from two 150-hp. Erie City horizontal water tube boilers and one 200-hp. Scotch marine boiler. This latter boiler has outlived its usefulness and cannot be relied on for regular service.

Owing to certain local conditions, this plant operates under difficult conditions. In the first place, there is no standpipe, so that the pumps have to deliver the water against direct pressure in the mains. Normally the pressure is kept at about 50 lb. per sq. in. at the pumps, but for fire service the pressure is raised to 100 lb. or 110 lb. and under extreme conditions to as high as 135 lb. In fact, there was one fire which assumed such serious proportions that the pressure was raised to 175 lb. Since practically all the large users of water have their own sources of supply, the daily pumpage is low for a town of the size of Fond du Lac (28,000 population) and yet the capacity must be great enough to handle any fire emergency. These extreme conditions of service make it difficult to get economical operation.

One of the most interesting features of the compressor itself is the fact that there are so few parts. There are only four bearings altogether—two main bearings, crankpin, and crosshead pin. The crankshaft, connecting rod, and piston comprise the sum total of all the moving parts. There is no piston rod or valve stem packing. There are no air connections except the intake to the low pressure cylinder and the discharge from the high pressure cylinder. The cooling water connections are eequally simple, as there is but one inlet and one discharge connection. With this cylinder arrangement there are just one-half the usual number of valves. The low pressure cylinder has one inlet and one discharge valve and the high pressure cylinder has one inlet and one discharge valve. The valves are all of the Nordberg automatic type, consisting of thin strips of metal mounted on a heavy cast iron cage which in turn fits in a port bored out of the cylinder casting similar to a Corliss port. The cage is clamped in position in the port in such a manner as to eliminate all leakage around the valves and so that it can be readily removed for inspection. The lubrication problem has been worked out in a very ingenious manner. The main bearings are ring oiling and are also supplied from the gravity system on the Diesel engine. The crankpin is oiled from the gravity system. The piston pin receives its oil from the

cylinder. An inclined groove is cut around the piston in such a manner that any excess of oil in the cylinder is collected in this groove. From there it is forced up through passages drilled in the piston and piston pin and so on into the piston pin bearing. Suitable checks keep these passages full of oil when the compressor is idle.

Three power cylinders comprise the Diesel engine which is of the vertical two-cycle type, developing 330 hp. at 225 r.p.m. A scavenging cylinder delivers air to the power cylinders at about 4 lb. pressure. This scavenging air is used to blow out the burned gases at the end of the power stroke and to furnish the fresh air supply. A three-stage air compressor furnishes air at about 1000 lb. pressure for the purpose of injecting the fuel oil into the cylinder. The entire cycle takes place in one revolution or two strokes. Toward the end of the

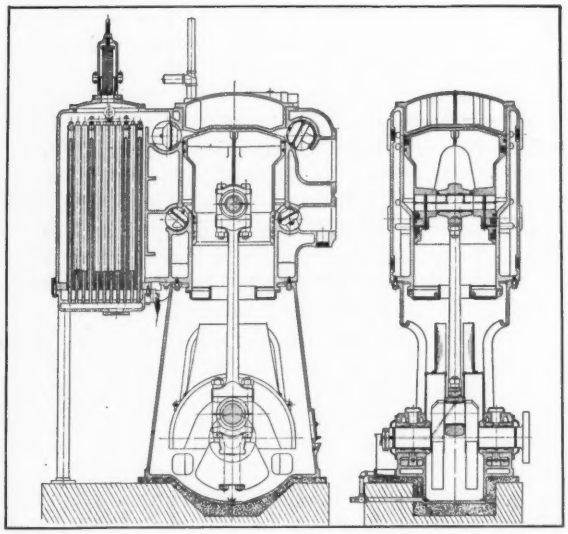


FIG. 2. HIGH PRESSURE CYLINDER OF THE COMPRESSOR IS BETWEEN THE BODY OF THE PISTON AND THE LARGE DIAMETER OF CYLINDER

power stroke the piston uncovers the exhaust ports which are along one side of the cylinder wall and the pressure in the cylinder drops to practically atmospheric pressure. As the piston travels further, it uncovers the scavenging ports, which are along the other side of the cylinder wall, opposite to the exhaust ports. The scavenging air being of higher pressure than the exhaust gases in the cylinder, blows the balance of the burned gases out and fills the cylinder with pure air which is trapped by the piston on the return stroke and compressed to about 450 lb. pressure. Into this highly compressed air, which rises in temperature to over 1000 deg. F., due to the work of compression, the fuel is sprayed through the fuel injection valve. The fuel is injected by means of air previously compressed to about 1000 lb. pressure. The beginning, as well as the duration of the fuel injection period, is governed entirely by the fuel valve which is controlled by a cam on the cam shaft.

Fuel pumps of the constant stroke are used. The governor holds the suction valve open during the suction stroke and a part of the discharge stroke. The point of the plunger stroke at which the suction valve closes is controlled by the governor and determines the quantity of oil delivered to the cylinder for that particular stroke.

Another feature of this engine is the fact that it is of the crosshead type. This feature makes it practical to use water cooled pistons, which fact greatly simplifies the cylinder lubrication problem and prolongs the life of the pistons themselves and the cylinder liners.

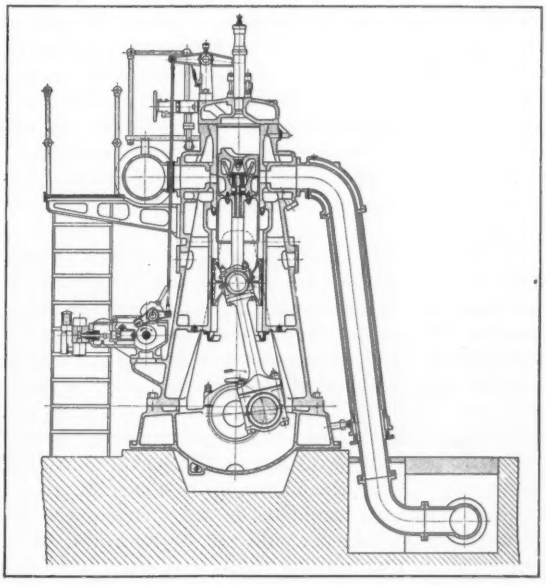


FIG. 3. POWER CYLINDER OF THE DIESEL COMPRESSOR UNIT

The use of a crosshead in place of a trunk piston makes it possible to increase the clearance between the piston and cylinder bore without causing any piston slap. This added piston clearance, together with the adequate cooling of the piston itself, prevents any possibility of the piston seizing in the cylinder.

One other advantage derived from having the piston water cooled is that it prevents the formation of carbon deposits. Practically all carbon deposits are formed from burned lubricating oil. In this engine, the lubricating oil enters the cylinder when the piston is at the lower dead center, is carried up along the cylinder wall during the compression stroke and thoroughly lubricates the cylinder walls. Both the cylinder walls and the piston are water cooled and are therefore kept well below the burning point of the oil. Means are provided for draining off all the excess oil fed to the cylinder so that it will not get into the fresh oil in the bedplate, as this oil is bound to get more or less contaminated from the foreign matter in the fuel.

Cooling water all goes through a cooling coil in the overhead lubricating oil supply tank; it then goes to the intercoolers and high pressure air compressor. From there it goes through a header distributing the cooling water to the cylinder, pistons, etc. This arrangement of putting all the cooling water through the intercoolers first reduces the work done by the air compressor to a minimum and also adds greatly to the life of the air compressor itself. The rise in temperature of the water in going through the air compressor and intercoolers is imperceptible, so that there is no loss on this account, while there is a very great gain. The water enters the

crosshead through a swinging arm, passes up through the hollow piston, circulates through the piston, and passes out through a tube in the piston rod and leaves the crosshead through a swinging arm opposite to the one it entered. This arrangement assures having the piston full of water at all times since there is no change in total volume, regardless of the position of the piston. This swinging arm device has been in operation for many years and is mechanically reliable and leak proof.

This unit has been in operation about a year and has been running from 12 to 20 hr. every day, taking the place of the old steam driven compressor which has been relegated to the position of a standby unit. The Diesel compressor has furnished all the air for the air lift with the exception of a few days when the fuel was allowed to run out. An accurate record was kept of the hours run and the amount of fuel used and the amount of free air compressed.

As has already been outlined, this plant operates under conditions that are unfavorable to economical operation. It is necessary at all times to be able to take care of any fire emergency that might come up. This means that a fire is kept under two boilers at all times. Since the normal pumping requires only about 40 boiler horsepower and 300 boiler horsepower are supplying this amount of steam, the boilers are operating normally at about 13 per cent of rating. Although the steam compressor would bring the boilers up to about 80 per cent of rating, this load would be on only part of the time and the total operation would not be improved to any great extent. This unfavorable steam plant operation, however, did not counterbalance the saving of the Diesel unit, as is evidenced by the fact that the present plant has been operating with an annual fuel bill of $7000 less than did the all steam plant.

Coal Dust from Mine Dump Causes Serious Accident

By C. A. Herbert*

FOR A number of years the Bureau of Mines has conducted experiments at its experimental mine near Bruceton, Pa., on the explosibility of coal dust, with particular reference to dust explosions in coal mines, and the knowledge so gained may well be applied to the handling of coal dust at industrial plants and elsewhere.

Powdered coal is coming into use more and more as a fuel, and the dangers incident to its use should be recognized and guarded against, as a number of accidents have occurred in recent years due to ignorance of this danger or to carelessness.

Within the past 3 yr., two very serious accidents under almost identical circumstances, have occurred on the surface at two different coal mines in southeastern Iowa, due in each case to the sudden ignition of a cloud of fine coal dust. The first accident resulted in the burning of six men, three of them fatally; the second burned eleven; three men died as a result of their burns.

In the southeastern part of Iowa, where these two disasters occurred, the mines are operated in a thin coal bed averaging about 3 ft. in thickness, and are worked on the long-wall advancing system similar to that of northern Illinois. The miners in this section are paid on the screened coal basis; in other words, receive no pay for the fine coal. As a result they use forks in loading the coal into the mine cars, and naturally a considerable quantity of coal is left along the roadways. Subsequently this fine coal, together with the roof rock that is taken down to give sufficient height on the roadways, is loaded into cars and dumped in piles on the surface. This roof rock is a black, oily shale, and the combination of fine coal and oil shale gives ample combustible material to burn the rock thoroughly as it is dumped.

These rock piles, or dirt piles, as they are called, take fire spontaneously and continue to burn as long as fresh material is dumped on them.

This rock, after having burned itself out, makes an excellent material for road building and also for railway track ballast. Because of this latter fact the railroads serving these mines were in each instance loading out the burned material from the side of the rock pile with a steam shovel. Having cleaned up all the loose material along the side of the pile next to the track, leaving a nearly perpendicular face, shots were placed in this straight face to bring down additional material for the shovel. In each case, a slide took place following the dynamite shots. These slides brought down with them a large quantity of the recently dumped and as yet unburned fine coal from the top of the dump; this fine coal being light, naturally separated out from the heavier rock material and thus formed a dust cloud.

As some of this fine coal was already burning along the outside of the pile where the air could get to it and all of it heated nearly to the ignition point, it was in just the right condition to flash into flame as soon as it was thrown into the air. The combined force of the slide and the rapid burning of the fine coal threw this burning dust cloud several hundred feet from the foot of the rock pile and across the railway tracks, burning those who were unfortunate enough to be in its path.

In the latter accident, the steam-shovel crew saw the slide take place and shut themselves in the steam-shovel cap to escape what they thought was a dust cloud, and thus escaped injury. The others who escaped were those who were fortunate enough to have run in a direction at right angles to the path of the flame.

One of the lessons learned from the study of dust explosions in coal mines is to keep the dust thoroughly moistened at the point where ignition is likely to occur. This acts in two ways to prevent a serious inflammation of the dust: First, the water tends to compact and bind the dust and prevent dust clouds from forming, and second, if sufficient water is added, it will cool the flame of any incipient inflammation sufficiently to extinguish it.

With the foregoing lesson in mind, it would be advisable for the railway companies engaged in loading up these old dirt dumps to wet down the freshly dumped combustible material at the top of the dump thoroughly for several days prior to its being disturbed. This could best be done by using fire hose with a pipe 5 or 6 ft. long for a nozzle, which should be forced down into the material on the top of the dump to make sure that the water reaches into the heated material beneath the surface.—Reports of Investigations, Department of the Interior, Bureau of Mines.

*Mining engineer, Bureau of Mines, Department of the Interior.

Automatic Feed Water Regulators for Steam Boilers

By Claude C. Brown

IN ANY given installation the success of the feed water regulator depends in a great measure upon whether or not the original installation was carefully and correctly made. There are a number of things that should be kept in mind in making such an installation, which if carefully adhered to, will prevent the greater part of future difficulty.

In the first place, the regulator should be secured rigidly so that there will be no possibility of its shifting out of place and out of adjustment. The principle upon which many feed water regulators operate, is the expansion and contraction of a metallic tube or element which is utilized through a system of multiplying levers to open or close the feed water control valve. In other words, the regulator is so set that the water level in the tube or operating element rises and falls exactly as does the water level in the water column on the boiler. As the boiler drum becomes filled with water, the actuating tube also becomes filled with water and contracts, thereby closing in on the feed water valve and decreasing the water supply. As the load increases and the water level in the boiler falls, the tube becomes filled with steam and expands, thereby opening the feed water valve and admitting more feed water. This floating operation continues and maintains the water level in the boiler at the proper point. Thus it is seen that in order for this mechanism to operate properly it must be rigidly installed so that the motion of the actuating tube which is comparatively small, will be fully utilized for the operation and control of the feed water valve.

On erection, the actuating tube or element should be placed so that its center will be at the same level as the normal water level of the boiler under average load conditions. It should be placed at such an angle that its length covers the desired vertical range of fluctuation of the water level of the boiler.

The steam connection, which is generally a ¾ or 1-in. line, should be run from the upper end of the actuating tube or element, to the highest point of the drum steam space. This line should be as short as possible and the greatest possible portion of it should be drained back toward the boiler at an appreciable pitch, not less than 1 in. per ft. Pipe bends should be used in place of elbows and the line should contain no pockets or traps. In order that the steam should be as dry as possible, this line should be insulated.

Ordinarily, the water connection, which is generally the same size as the steam line, should be run directly downward from the lower end of the actuating tube for a distance of 8 to 12 in. and thence to the water space of the boiler drum. This line should be at least 8 ft. long and connect if possible directly into the boiler drum at a point below the lowest desired water level of the boiler. No part of it should be more than 3 ft. below the connection to the boiler. Unlike the steam connection, this line should not be insulated for it must radiate as much of the heat from the water it contains as possible. It is highly desirable that the steam and water connections to the regulator be made to the same drum, as any differences in pressure between drums is thereby obviated. A valve should be placed in this water line as close to the boiler as possible. A nipple and a valve should be placed in the casting at the lower end of the actuating tube so that it may be periodically blown off to remove any sediment or foreign matter that may have collected.

Preferably the control valve should be placed in a horizontal run of the boiler feed line and both the control valve and that portion of the feed line adjacent to it should be rigidly anchored. The strut connecting the control valve lever and the lever from the actuating tube should be vertical, all side thrusts or bending strains being eliminated. Every effort should be made to facilitate the transmission of all of the expansive force of the actuating tube to the control valve, with the least possible loss due either to slack connections or to binding.

After a regulator has been installed, it should be thoroughly blown out to remove all air and sediment, chips or other foreign matter that may have found its way into it during construction. It should then be put on the line by opening the water valve, the steam valve remaining closed, until the tube or element is filled with water. In about 1 min., the water valve should be closed. The steam valve should then be opened after which the blowoff valve should be opened and the steam allowed to blow through the tube for a period of several minutes. The adjusting nuts should be slackened off during this operation. The regulator blowoff valve should then be closed and the water valve opened. In about 20 min. the temperature of the regulator should reach normal. The regulator may now be adjusted by means of the adjusting nuts so that the valve lever is horizontal. The hand feed should then be opened wide and the boiler feed controlled by the regulator.

During operation, the regulator should be operated by hand several times each day to insure its free operation and to prevent the control valve from becoming set. A close watch should be kept for the formation of boiler scale in all parts of the apparatus and a regular practice of semi-annual cleaning should be kept. Once the regulator has been set or adjusted for a given load on a boiler, it is not advisable to change that adjustment unless it is absolutely necessary for the reason that frequent changing of the adjustment of regulators has been found to be detrimental to their operation.

Skimmer and Blowoff Installation

It was my privilege, not long ago, to erect a new power plant at a location where the water is supposed to be soft. With only a bottom blowoff, priming gave considerable trouble after only two weeks running. It was thought that if the sludge could be removed as fast as it was formed, a longer time could be allowed between washings. Accordingly a 2-in. pipe connection was tapped through the back head and a 2-in. pipe was run about half the length of the boiler, just below the normal water level. The end was capped and a number of 5/16-in. holes drilled in two rows sufficient to give a total capacity a little less than that of the pipe.

By blowing down for about ½ min. at a time every 2½ hr. while operating and using the bottom blowoff four times a day, the boilers could be run the entire season without washing. S. P. Morrison.

TABLE OF GENERAL SPECIFICATIONS FOR PIPING

Service	Pipe Size	Pipe	Fitting	Valves	Gaskets	Insulation
Steam						
250 lb. pres. 100 deg. F. sup.	2 in.	Extra heavy	Extra heavy cast steel screwed	Extra heavy brass, globe or gate		1½ in. fire felt or equiv.
250 lb. pres. 100 deg. F. sup.	2½ in. up	Extra heavy, forged or cast steel flanged	Extra heavy cast steel flanged	Extra heavy, cast steel, monel trim	1/16 in. compd. asbestos	1½ in. sponge felt or equiv.
150 lb. pres. 100 deg. F. sup.	2 in.	Standard weight	Extra heavy cast iron screwed	Medium brass, globe or gate		1 in. sponge felt or equiv.
150 lb. pres. sup. (yd. lines)	2½ to 8 in.	Standard weight	Extra heavy cast iron screwed	Medium semi-steel, gate, brass mtd.	1/16 in. compd. asbestos	1½ in. sponge felt or equiv.
150 lb. pres. 100 deg. F. sup.	2½ in. up	Std. wt. pipe. Ex. heavy c.i. flanges	Extra heavy cast iron flanged	Medium semi-steel, gate, brass mtd.	1/16 in. compd. asbestos	1½ in. sponge felt or equiv.
25 to 125 lb. saturated	3 in.	Standard weight	Std. cast iron screwed	Std. brass, globe or gate	1/16 in. compd. asbestos	1 in. sponge felt or equiv.
25 to 125 lb. saturated	4 in. up	Std. wt. std. cast iron flanges	Std. cast iron flanged	Std. iron body, brass mounted	1/16 in. compd. asbestos	1½ in. sponge felt or equiv.
0 to 25 lb. saturated	0 to 4 in.	Standard weight	Std. cast iron screwed	Std. brass		1 in. air cell or equivalent
0 to 25 lb. saturated	4 to 12 in.	Std. wt. std. c.i. screwed flange	Std. cast iron flanged	Std. iron body, brass mounted, gate	1/16 in. red rubber	1 in. air cell or equivalent
0 to 25 lb. saturated	14 in. up	Std. wt. std. c.i. screwed flange	Low pres. cast iron flanged	Low press. iron body, brass mtd., gate	3/32 in. red rubber	1 in. air cell or equivalent
Water						
Up to 150 ft. head, cold	2½ in.	Standard weight	Std. cast iron, screwed	Std. brass, gate		
Up to 150 ft. head, cold	3 to 6 in.	Standard weight	Std. cast iron, screwed	Std. iron body, brass mounted, gate	Paper	
Up to 150 ft. head, overhead	8 in. up	Standard weight	Std. cast iron, screwed or flanged	Std. iron body, brass mounted, gate	Paper	
Up to 150 ft. head, undergrd.	8 in. up	C.i., class "B," bell and spigot	C. iron class "B," bell and bell	Std. iron body, brass mounted, double bell		
Up to 150 ft. head, hot	To be the	same as cold water service except	use rubber gaskets			Depends
100 lb. yard fire lines	6 in. up	C.i., class "C," bell and spigot	C. iron class "C," bell and bell			
Calcium Brine		Standard weight	Std. cast iron, screwed or flanged	Std. all iron gate		Inside—cork. Outside—hair felt
Oil						
Cold oil	2½ in.	Standard weight	Std. malleable screwed	Std. brass gate		
Cold oil	3 in. up	Standard weight	Std. cast iron screwed or flanged	Std. iron body, brass mounted, gate	1/16 in. paper	
Hot tar	4 in. up	Extra heavy	Ex. heavy malleable screwed	Ex. heavy, cast steel	Compressed asbestos	
Air						
125 lb. maximum	2½ in.	Standard weight	Standard cast iron screwed	Std. brass gate		
125 lb. maximum	3 in. up	Standard weight	Standard cast iron screwed	Std. iron body, brass mounted, gate	Paper	
Ammonia	2 in.	Extra heavy	Ammonia	Semi-steel ammonia		
Gas						
125 lb. maximum	2½ in.	Standard weight	Standard cast iron screwed	Std. brass gate		
125 lb. maximum	3 in. up	Standard weight	Std. cast iron screwed or flanged	Std. iron body, brass mounted, gate	Paper	
Vapor Lines		Standard weight	Ex. heavy malleable iron screwed or ex. heavy cast iron flanged		Compressed asbestos	Depends
Acid						
Weak	2 to 4 in.	Bronze or lead	Bronze flanged or lead	Bronze or lead lined, flanged	Asbestos	
Strong	2 to 4 in.	Standard weight wrought iron	Std. cast iron flanged	Std. iron body, brass mounted, flanged	Asbestos	
Alkali	2 to 3 in.	Standard weight	Std. cast iron screwed	Standard gate		

Selection of Piping Equipment

GOOD JUDGMENT AND CAREFUL STUDY OF LOCAL CONDITIONS ARE ESSENTIALS FOR A SATISFACTORY PIPING JOB

STANDARD PRACTICE in the selection of pipe, fittings and valves has not become uniform among engineers or industrial concerns. While practice has taught that certain fundamentals, which are relatively few in number, work out most satisfactorily from the investment and safety standpoints, it is unquestionably true that in most instances the purchaser or user may exercise considerable leeway in his judgment when it comes to the selection of this kind of equipment.

On the page opposite is given a table which was drawn up by a large industrial concern as a standard practice sheet for the guidance of their engineering department and those directly responsible for the purchase and use of pipe and accessories. They further specified that all high pressure steam line gate valves 8 in. and larger shall be provided with bypass valves.

Probably the first question to arise in the selection of wrought pipe is whether steel or iron should be specified. This is greatly a matter of preference and no definite rule can be established. Recently methods have been devised by which wrought iron pipe can be successfully Van Stoned. This development will no doubt broaden the use of wrought iron because heretofore those preferring that type of joint were compelled to specify wrought steel. For hot water service some engineers specify brass pipe, which is high in first cost; however, the use of this material is an assurance against pitting and corrosion. Modern methods of feed water treatment have made the use of either wrought iron or wrought steel satisfactory for boiler feed lines.

All important main line valves in the larger sizes should be of outside stem and yoke construction, because a glance at the projection of the stem will tell the operator whether the valve is open or closed. The seating faces of discs and seat rings should be renewable, and the bonnet should be arranged for back seating when the valve is open so that it may be packed when under pressure.

STEAM PRESSURES OF 250 LB., SUPERHEATED

For steam pressures ranging above 150 and up to and including 250 lb. it is advisable to use extra heavy pipe for 7 in. and smaller. Sizes larger than 7 in. should be of the following weight per foot of thickness: 8 in. 28.55 lb., 9 in. 33.90 lb., 10 in. 40.48 lb., 12 in. 49.56 lb., 14 to 16 in., inclusive, ⅜ in. The boiler feed, blowoff and drip lines for the foregoing pressures should preferably be of extra heavy pipe and the fittings should be the same as specified for the steam pressure with which they are used. The type of joint to be used is somewhat a question of preference, although the welded, Van Stone, or the Sargol (Patented) joints, are the most often used and will no doubt give the best results.

For pressures ranging from 125 lb. to 150 lb., standard full weight pipe may be used up to and including 7 in. Sizes larger than 7 in. should be of the following weight per foot or thickness: 8 in. 24.69 lb., 9 in. 33.90 lb., 10 in. 34.24 lb., 12 in. 43.77 lb., 14 to 20 in., inclusive, 5/16 in. thick. The boiler feed, blowoff and drip lines should correspond in weight to that specified for the steam pressure with which they are installed. It may be advisable in order to gain extra life to put the boiler feed line in of extra heavy pipe. The valves and fittings should correspond in weight with the pipe on which they are used except that it may be advisable to use extra heavy valves and fittings and blowoff lines where the service will be most severe. Extra heavy flanged cast iron pipe is satisfactory for buried blowoff lines. The connection from the blowoff tank to the sewer should also be of cast iron pipe for the reason that the sudden changes of temperature will ruin tile drain pipe. If this connection is more than 100 ft. long it will not be necessary to extend the cast iron pipe more than about 100 ft. from the blowoff tank. Tile may then be laid from that point to the connection at the sewer.

Welding on steam lines is permissible where it is advisable economically. Branches may be welded to main piping in preference to the use of fittings. The welded branch may eliminate either one or two joints, which will often prove an advantage over the use of gasket packed joints at these points. All welds should receive a hammer test under a hydrostatic pressure of three times the working pressure. The fillets on branches, if butt welded, should be built up to a radius equal to not less than three times the thickness of the pipe wall.

Bolts up to and including 1½ in. in diameter which are to be used for flange connections should have square heads and U. S. standard threads. The nuts should be hexagonal, cold punched, chamfered and trimmed. For bolts larger than 1½ in. studs with two nuts should be used. The bolt thread when pulled up should extend completely through the nut. For high pressure work, particularly where semi-finished bolts and nuts are used, it is desirable to have a better bearing surface for the bolt and nut than can be obtained with rough castings. This is obtained by spot facing the bolt holes or by finishing the back of the flange.

Gasket selection varies greatly among different users. The compressed asbestos gasket will serve for a great many purposes, including high pressure steam, hot water, etc. It does not deteriorate in storage and therefore often proves an economical gasket material to have on hand. On new work where the flange faces are clean and square a gasket thickness of 1/32 in. will prove satisfactory. On remade joints or where the flanges are not in the best of condition it will probably be best to use gasket material 1/16 in. in thickness. Metal gaskets are also used for pressures up to 250 lb. The Sargol joint is welded steam tight, the weld serving only in the capacity of sealing the joint, all strain being taken by the bolted flanges.

Good rubber gasket material or corrugated asbestos filled copper gaskets may be used for saturated steam, boiler feed, blowoff and drain lines. Exhaust lines may be made up satisfactorily with rubber gaskets. Cloth inserted rubber gaskets will make good joints in suction lines. Cold water lines at low pressure may be made up with rubber gaskets; however, for pressures above 100 lb. it will be best to use wire inserted gaskets.

Covering for piping should preferably be of the sectional removable type and of such construction that it will not sag away from the pipe should it become damp or wet. Valves and fittings should be covered with the same thickness of insulating material as that on the pipe system of which they form a part. Insulation for this service may be in either block or plastic form. A canvas protecting jacket should cover all insulating material, this jacket to be given two coats of asbestos paint the color of which will be determined by the service or the surrounding color scheme.

Pipe supports or hangers should be so placed that their working stresses shall have a factor of safety of not less than six, assuming that each hanger is bearing its proportion of the load with the line full of water. Pipe anchorage must be provided as local conditions necessitate.

In most power plant work, concrete is used for basement floors. For permanency all drain pipe buried beneath concrete should be cast-iron soil pipe. The use of the extra heavy weight will greatly reduce breakage when calking joints.

Handling Oil for Use in Power Plants

By C. W. Geiger

BECAUSE OF THE widespread use of oil as fuel in the power plants in the vicinity of Oakland, Berkley, Alameda, etc., the Associated Oil Company has had to work out a solution to the problem of supplying oil to those plants. This resulted in the recent erection of one of the largest and most complete oil stations on the Pacific Coast.

This plant, views of which are shown in the accompanying illustrations, is located on the Oakland Estuary on the Alameda shore, and possesses both railroad and dock facilities. A large fleet of oil trucks is engaged in supplying petroleum products to the power plants of various manufacturing concerns within a radius of 25 mi. or more.

At the plant, there is a loading rack where six oil trucks can take oil at one time. There are two steel tanks for the storage of crude oil, one tank having a capacity of 30,000 bbl. and the other 37,000 bbl. Tanks for gasoline, distillate, kerosene, etc., are also provided. All tanks are entirely surrounded by high concrete walls.

There are two separate pump rooms, the pumps in one room handling only crude oil, and the pump in the other refined oil.

Three pumps are provided for handling refined oils one being a 3-in. centrifugal pump of 250 gal. per min., direct connected to an electric motor for handling gasoline, and a similar pump is used for handling distillate. For handling kerosene, there is a 2-in. centrifugal pump of 100-gal. per min. capacity.

These pumps deliver the refined oils to a loading rack for delivery to tank cars, and they also deliver to gage tanks of 2000 gal. each, which are located over the pump room, and from these gage tanks the refined oils are delivered by gravity to the filling or loading rack for the oil tank wagons.

At the car loading rack, the piping is so arranged that crude or refined oil may be delivered into tank cars or pumped from tank cars. The three refined oil pumps are interchangeable in that they can be operated independently of each other.

There are two crude oil pumps, one being a rotary pump direct connected to a 50-hp. electric motor and capable of delivering 650 bbl. of crude oil, from storage tanks. The crude oil is received at the plant by oil tankers, the pumps on these tankers pumping the oil from the cargo tanks to the storage tanks at the plant; but if necessary the two crude oil pumps can handle this oil. A small boiler is used for heating crude oil in cold weather.

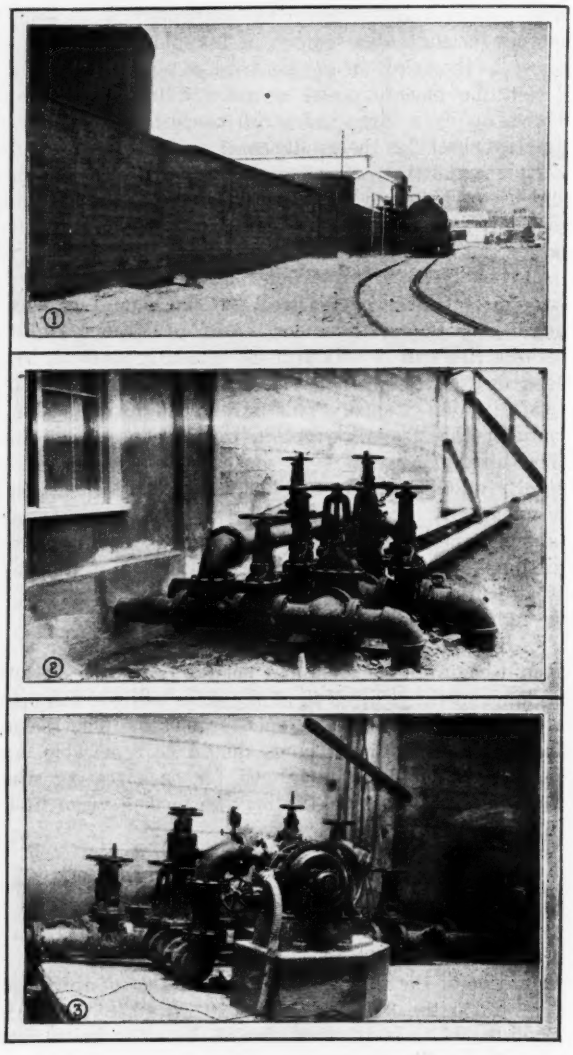
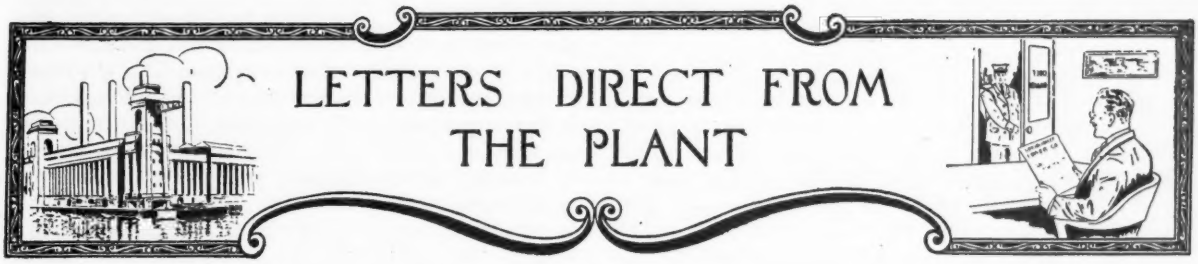


FIG. 1. OIL UNLOADING RACK FOR HANDLING OIL TO OR FROM OIL TANK CARS

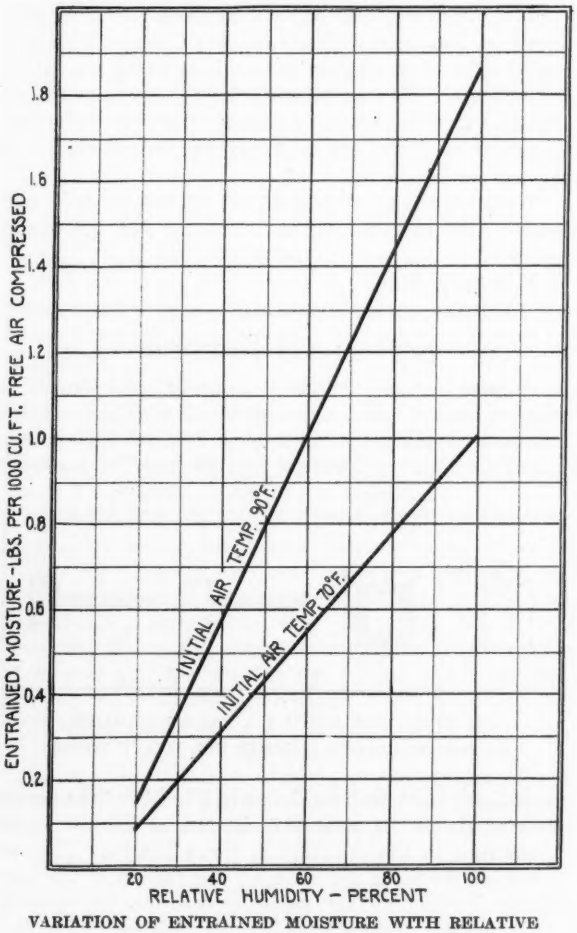
FIG. 2. VIEW OF VALVES IN SYSTEM FOR HANDLING CRUDE OIL

FIG. 3. ONE OF THE ELECTRICALLY DRIVEN PUMPS INSTALLED AT THE OIL STATION OF THE ASSOCIATED OIL CO. AT ALAMEDA, CAL.



Water in the Air Line

IN ANY compressed air plant there is always a certain amount of entrained moisture that one must contend with in the air lines. And in almost every use to which compressed air is put this moisture is objectionable. If one wishes to cool an overheated motor with an air hose, he does not want to spray the armature or commutator with water. He wants dry air. Entrained moisture is also objectionable in the use of air engines and pneumatic tools such as air hammers and drills. In some plants compressed air is used to force liquids from one tank into another, and it may be undesirable to have any water from the air mix with these liquids.



VARIATION OF ENTRAINED MOISTURE WITH RELATIVE HUMIDITY AND INITIAL AIR TEMPERATURE

Before this water got into the air system, it was nothing but water vapor in the outside air. Out in the free air, it stayed in the form of a vapor; but in the process of compression, it was separated out.

Suppose that air is being compressed to 100 lb. gage pressure and that the air temperatures before and after compression are 70 deg. F. Take the atmospheric pressure as 15 lb. per sq. in absolute. Assume that the relative humidity of the outside air is 80 per cent. A table on mixtures of air and saturated water vapor shows that a cubic foot of air contains 0.001,152 lb. of vapor when saturated at 70 deg. F.; but since the relative humidity in our case is 80 per cent, we have only $0.001,152 \times 0.80$, or 0.000,922 lb. of vapor per cu. ft. in the outside air.

With every 1000 cu. ft. of free air going into the compressor there is also 0.922 lb. of water vapor. Now, in compressing this air from 15 lb. per sq. in. absolute to 115 lb. absolute (100 lb. gage), we reduce the volume from 1000 to $1000 \times 15 \div 115 = 130$ cu. ft. We know that the greatest amount of water vapor a cubic foot of air can hold at 70 deg. F. is 0.001,153 lb., or the greatest amount 130 cu. ft. can hold is 0.1504 lb. But since 0.922 lb. of vapor entered the compressor, we find that 0.922 — 0.1504 or 0.772 lb. must have been condensed out. Hence, for the conditions we assumed we get 0.772 lb. of entrained moisture with every 1000 cu. ft. of free air compressed.

The chart shows how the amount of entrained moisture varies with the relative humidity of the outside air when the air temperature before and after compression is 70 and 90 deg. F. It is true that the air temperature at the discharge of a compressor is considerably higher than at the intake, but the air cools off in the receiver to the outside air temperature again.

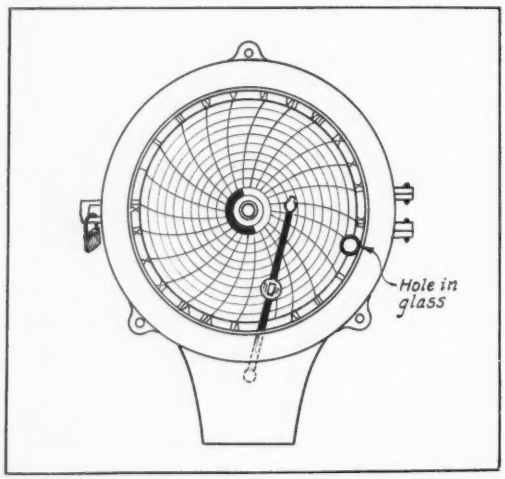
Suppose an air compressor has a capacity of 2500 cu. ft. of free air per min. with a receiver air pressure of 100 lb. gage and that the outside air has a temperature of 90 deg. F. and a relative humidity of 70 per cent. The chart shows that 1.22 lb. of entrained moisture will enter the air system with every 1000 cu. ft. of free air compressed. This would make the total moisture 183 lb. per hr., which is an appreciable amount.

One of the principal functions of the air receiver is to remove entrained moisture. A receiver should be of ample size so that the heated air will be allowed to pause in its flow and to cool sufficiently to permit of its dropping most of the entrained moisture. The water thus accumulated can be discharged at proper intervals through suitable drains. An after-cooler is a more effective moisture remover, because a more complete cooling is obtained with the water cooled pipes used. One or two separators are sometimes necessary on a long air line. They should be drained by suitable traps. It is a good plan to give the air line between the separators a gradient of one or two per cent, so that the separators will be at the low points in the line.

Oak Park, Ill. M. A. KOLB.

Recording Pressure Gage Makes an Efficient Watchman's Clock

WISHING to know whether the watchman made steady and periodic rounds to the power plant in the basement, the superintendent of a large Pittsburgh office building developed a really novel use for the ordinary pressure recording gage. By cutting a small hole in the glass door of the gage and in line with the pen arm, it was possible for the watchman to insert a rubber end lead pencil in the hole and mark the chart on each visit to



A SMALL HOLE CUT IN THE GLASS DOOR TRANSFORMS ANY RECORDING GAGE INTO A WATCHMAN'S CLOCK

the power plant. By pressing the rubber end of the pencil to an ordinary red ink stamp pad, such as is found in any office, and pressing the inked rubber against the chart through the hole in the glass door a red mark was left on the chart. As the glass is close to the chart, no amount of manipulation of the pencil could make more than 15 min. difference in the time. As the hole is cut near the outer edge of the chart, these marks do not interfere with the record traced by the pen arm. This gage is, of course, kept locked and it is possible to falsify the watchman's record only by picking this lock.

Pittsburgh, Pa. JOHN H. SCHALEK.

Sawdust and Coal Make a Free Burning Mixture

WHEN WE had our coal bin filled with a lot of slack coal that resembled black sandy mud more than it did a pile of coal, we found ourselves at a loss as to how best to burn it on our grate. The engineer tried all possible means at hand and was not making much progress until he tried out the solicited suggestion of one of his men that he mix sawdust with the coal.

When the slack coal was fired it almost completely stopped the draft and consequently checked the fire. Quantities of smoke were given off, as not enough air could be induced through the fuel bed. Any attempt to work the fire so as to get more air through the fuel resulted in allowing slack coal to fall through the grates.

On mixing sawdust with the coal in the proportion of one to two by volume, it was found that during the first stages of combustion the sawdust gave off a gas having a lower ignition temperature than that of the coal, which on burning raised the temperature of the mixture and ignited the coal gas.

Sawdust, being of a more volatile nature than coal, is consumed rapidly, and the space that was originally occupied by the small particles of wood is subsequently vacant. The coal bed then somewhat resembled a sponge through which air could easily pass.

As the coal was consumed, these small holes grew larger, but the bed of fuel held its shape much better than was expected and required little or no working. Fresh fuel could be applied on top of this foundation with less trouble in keeping the bed free from hills, hollows or holes.

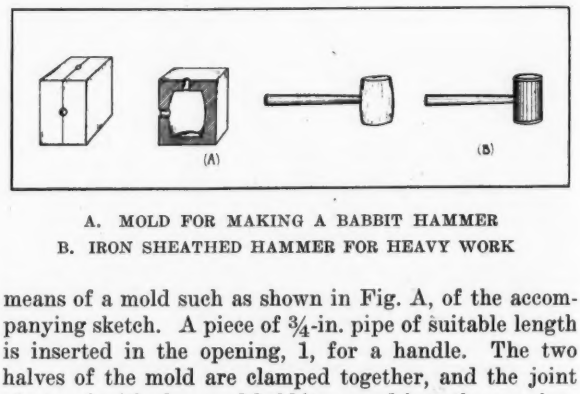
After this experiment, we immediately ordered a supply of sawdust, which costs very little, 3 cents a cubic foot, and weight for weight is as cheap as coal, on a B.t.u. basis. The extra work for the fireman did not amount to that required for firing with coal alone, and we found after a short run that we had effected a 30 per cent saving in fuel costs.

We have since put in a supply of better grade fuel, but we still use the sawdust mixture with gratifying results.

Winnipeg, Man. C. RYE.

Soft Metal Hammer

A SOFT metal hammer is a useful tool around a power plant; it often saves polished work from being marred and takes the place of a hardwood block and hammer. Such a hammer can be readily made by



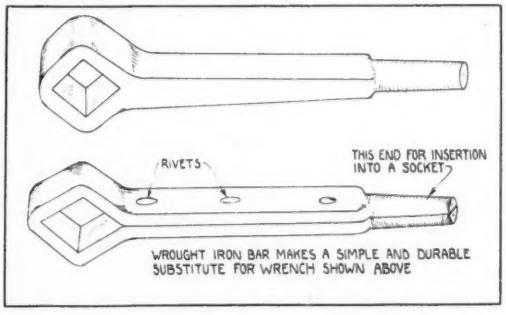
A. MOLD FOR MAKING A BABBIT HAMMER
B. IRON SHEATHED HAMMER FOR HEAVY WORK

means of a mold such as shown in Fig. A, of the accompanying sketch. A piece of ¾-in. pipe of suitable length is inserted in the opening, 1, for a handle. The two halves of the mold are clamped together, and the joint plastered with clay, and babbit poured into the opening, 2. After the metal has cooled, the mold can be opened and the hammer easily removed. When the hammer has been battered out of shape, or broken through usage, it can easily be remelted. A sledge used on this soft hammer will soon break it. For heavier work, the hammer shown in Fig. B may be used. It consists of a short piece of 3-in. pipe, drilled as shown for a ¾ or 1-in. pipe handle. Fasten a piece of tin around the ends in order that the babbit when poured will project beyond the end of the pipe a short distance. A hammer made in this manner can be used with a sledge on heavy work and is not liable to break on account of the iron casing. TOM JONES.

Substitute for a Cast Iron Box Wrench

CAST-IRON WRENCHES similar to those used to operate furnace grate bars, are readily fractured and replacement is sometimes difficult or involves a delay. Repair of broken wrenches, even with welding, does not seem practicable and where these have been welded, only in some exceptional cases has this method of repair proved durable.

Construction of a wrench for this purpose is not difficult and an illustration of a simple wrench which one mechanic constructed is given in the appended sketch. Apart from the simplicity of this box wrench,


RIVETS
THIS END FOR INSERTION INTO A SOCKET
WROUGHT IRON BAR MAKES A SIMPLE AND DURABLE SUBSTITUTE FOR WRENCH SHOWN ABOVE

WROUGHT IRON WRENCH MAKES A SIMPLE AND DURABLE SUBSTITUTE FOR CAST-IRON TOOLS

wrought iron used in the wrench has proved to be most suitable for the purpose and more durable than the original.

In the wrench illustrated, a strip of wrought iron, ½ in. thick and 1½ in. wide, is forged to the required square shape, rivets are put in to hold the two sections together and the end is made into an inserting tool for use in the socket for dumping the grate.

As the sketch will indicate, the wrought iron bars can be used to make satisfactory substitutes in many instances for the usual cast iron tool that is generally used for furnaces and other machinery. For the smaller section of the wrought iron, this can be handled by cold bending. They can easily be made up from odd lengths of iron by any mechanic or handy man about the shop and can be made any size desired.

Washington, D. C. G. A. LUERS.

Change in Piping to Prevent Water Hammer

WE HAVE recently had some trouble with our return system to the boiler, due to water hammer. When the return trap to the boiler was operating, with the boiler feed pump running, there was severe water hammer immediately following the dumping of the trap. With the trap operating alone and vented to the atmosphere, the water hammer was almost as bad. A diagram of the piping layout as it was at this time is shown in Fig. 1. It will be noted that there is a 9-ft. drop in the return lines to the header, that all joints are made with tees and unions, and that all the return lines are of the same size as the header, 1¼ in., with the exception of one ¾-in. return.

When the trap was in the filling position, steam was always to be seen coming from the exhaust head; it was reasoned that the evaporation of the returns was the cause. Such was not the case, however; for on examination, it was found that the valves were badly in need of a renewal and that live steam was blowing through. The valves were reground and that loss was eliminated. Next was to find and eliminate, if possible, the water hammer.

In the first place, we eliminated all the tees in the system by arranging the piping as shown in Fig. 2. With this arrangement, all the returns flowed in the same

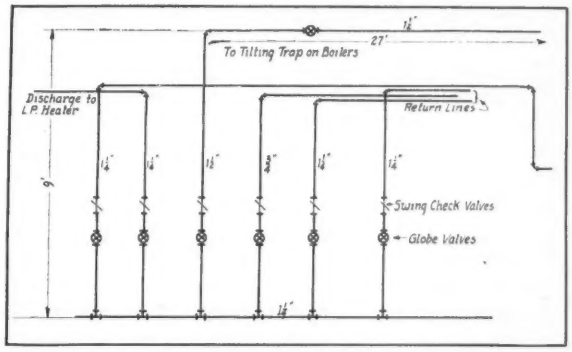


FIG. 1. DIAGRAM OF PIPING THAT CAUSED WATER HAMMER

direction in the header to the lead to the feed trap. "Y's" were substituted for the tees and the excessive drop to the return header was reduced.

We tried several experiments. First the valve on the line to the low pressure heater was closed so that all returns were delivered direct to the return trap, a gage being placed as shown in Fig. 2. As soon as the return trap fell to dumping position, a severe water hammer occurred and the gage needle made a revolution and a half, sufficient to break the hair spring. The valve to the heater was then opened enough so that when the

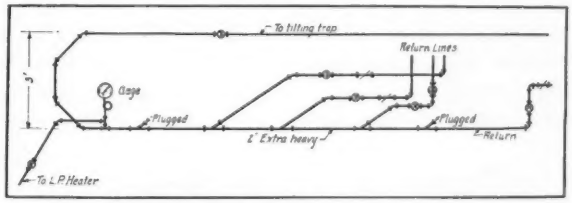


FIG. 2. WATER HAMMER WAS ELIMINATED IN THE INSTALLATION

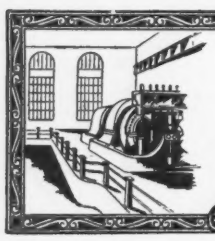
trap went to dumping position, the gage (new) registered boiler pressure, then slowly fell back to zero. The various returns were tried separately, but water hammer still resulted.

These experiments showed the necessity of a vented receiver tank, the return trap to take the returns direct from the tank.

Worcester, Mass. LEROY BLAKE.

Correction Note

IN OUR Sept. 1 issue, on page 877, appeared an article "Standards for Tongue and Groove Joints." A reference was made to a similar article on the "Sargol Joint" as having appeared in our July 15 issue. This was in error, as the latter appeared on page 819 of our issue of Aug. 15.



PROBLEMS IN OPERATING POWER EQUIPMENT

Flow of Gas Is Function of Density

WHEN ANY gas is allowed to flow through a given orifice under a fixed constant pressure and at a constant temperature, it is stated that the rate of flow is inversely proportional to the square root of the density. I do not quite understand why this should be so. Will you please explain? B. F. G.

A. The rate of flow of a gas through a small sharp edged orifice may be deduced from the principle of the conservation of energy. Each particle of gas has, as it passes through the orifice, a certain velocity, v, and therefor a certain kinetic energy, $\frac{1}{2}mv^2$. The work done in expelling this gas is obviously equal to the product of the pressure difference, P, and the volume, V, displaced. If it be considered that there is no loss due to friction of gas in passing through the orifice, then the work done must equal the kinetic energy, i. e.,

$$PV = \frac{1}{2}mv^2$$

If the density of the gas is d, then the mass, m, of the volume, V, is Vd. Substituting this value for m in the expression $\frac{1}{2}mv^2$, we have

$$PV = \frac{1}{2}Vdv^2$$

Dividing each side of the equation by V and solving for v^2, we have
and

$$v^2 = 2P \div d$$

$$v = \sqrt{2P \div d}$$

Thus if the pressure difference is maintained at a constant value, it will be seen that the velocity of efflux is proportional to $\sqrt{1 \div d}$, or inversely proportional to the square root of the density.

Change in Furnace Design to Prevent Smoke

IN REGARD to the inquiry by F. G. F. on page 796 of the Aug. 1 issue of Power Plant Engineering, concerning changes in furnace setting, I would suggest that he make the distance between the grate surface and bottom row of tubes at least 48 in. if possible, and even 5 ft. would be better for burning wood.

Smoke is the result of incomplete combustion, for which there are three primary causes; all others may be considered as contributory or incidental.

First: Lack or incomplete application of air. Unless the air is supplied in such a way as to insure proper distribution to the fuel on the grates and proper mixture with the combustible gases arising from the fuel, combustion will likely be incomplete.

Second: Low temperature. The speed of all chemical reactions depends upon the temperature and excess air is one of the principal, and I think, the most common cause of it.

Third: Lack of space is a common cause of smoke. The gases are moving while in the process of combustion, and if the flame encounters cold, or relatively cold surfaces, combustion will be checked, and carbon will be precipitated. To allow for the completion of the combustion we need space in a boiler furnace, and more of it than is commonly provided.

Low settings and restricted spaces for combustion probably cause more smoke than all the other causes combined. The tendency at the present time is to design the boiler setting so as to give more space between the grate surface and boiler, as well as in the combustion chamber, and it is not uncommon to see, and in fact it is advocated that the distance between the grate surface and boiler shell be at least 48 in. for burning bituminous or long flaming coals, and when burning wood, which has a longer flame, the distance should be even greater.

One of the problems in the economical generation of steam is to get the gases, not the flame, into contact with the boiler heating surfaces and with as much of the heating surface as possible.

Referring to the drawing submitted by F. G. F., I notice that the distance is only 36 in. from the grates to the bottom row of tubes. This is certainly not enough for burning wood.

In regard to the auxiliary air feeding device, I assume that a device for introducing a supply of air over the fire is what is referred to. I think the first problem to solve is whether or not more air is needed; I would suggest that an inexpensive test be made before going to the expense of installing the necessary equipment. This test can be made by allowing the furnace doors to remain partly open for a few moments after each firing and noting the results. If it is found that the admittance of air over the fire is an improvement, I would suggest that the air be admitted through slot openings made above the furnace doors. These openings should be fitted with dampers and gradually closed to meet the requirements after each firing.

E. C. W.

Scale in Feed Pipe Line; Will Two Feed Water Systems Be Necessary?

REPLYING TO G. T.'s question concerning the formation of scale in the feed pipe line, on page 796 of the Aug. 1 issue of Power Plant Engineering: The scale formation in the feed pipe line is probably due to chemical action of the feed water, after being heated in the heater; it also appears that the velocity at which the water passes through the pipe is extremely low or more of this sludge would be deposited in the boiler. Galvanized iron pipe will quickly choke up with scale and have to be renewed about every 8 to 10 mo., with some kinds of water. Iron pipe will also choke up, but not so

quickly. Brass pipe chokes up in time but will last a few years before getting to a condition requiring dismantling and renewing in cleaning it.

It is not advisable to place a filter between the feed pump and the boiler, as the filtering of the water is accomplished to better advantage when it is allowed to flow through the filter by gravity. If an open heater were used, and clear water heated by exhaust steam up to 180 or 210 deg. F., the cylinder oil and much of the impurities would be deposited out in the filtering bed at the bottom of the heater, or much of the oil could pass out through the overflow from the oil separator and not enter the filtering chamber.

In replying to A. C.'s question on the same page, I would say that two feed water systems would be far more reliable and give far better service than the system he mentions. If 150 lb. pressure is needed at all times on this one boiler, it would be safer to operate it separately from the others. In case anything happened to the reducing valve, it would over-tax the capacity of the safety valves on the lower pressure boilers and might cause broken safety valve springs or other more serious damage to some of the boilers. For this reason, some state boiler laws require that safety valves on boilers in a battery all be set at the safe pressure of the boiler carrying the lowest allowable working pressure, so that an over-pressure will not be put on boiler by the sudden failure of a reducing valve.

To feed one boiler at 150 lb. and the others at 120 lb. would cause the feed water to rush through the feed valves on the 120 lb. boilers at great velocity and cut the discs and seats out quickly. If hand operation were used there would be unstable action of the pump due to the attendant's inability to keep the valves all even enough to maintain a steady pressure on the feed water main. There is always danger of flooding the low pressure boilers and the unstable movement of the feed pump would rob the new boiler of its feed water. This happens so quickly and the damage is so great that the risk is too great to be thought of. Even if a pump governor were used and feed water regulators were installed on each boiler the wear on the valve seats and discs would be severe. I should suggest using an injector for this new boiler or installing a separate feed pump and heater for it.

We have five water tube boilers which ordinarily carry 150 lb. pressure but No. 5 boiler is made to carry 250 lb. for special tests. We often carry 175 lb. on it, but the 250 lb. tests are less frequent. We have injector for feeding when necessary, but on 250 lb. pressure it is not as relable as a pump, consequently we use a hydraulic ram type feed pump most of the time when running above 150 lb. pressure. When all boilers are running together we cut out this pump and heater and feed from the other feed pump and heater through economizers. Have no trouble in changing over. First slow down the feed pump and let the pressure run down a little on the high pressure boiler, check the fire a little on the others and then open the stop valve on the header, usually the bypass first if 250 lb. is used, but the main valve if 175 lb. is carried. The difference in pressure prevents the valve being opened too quickly and if the safety valve on any other boiler pops, just leave the stop valve partly open until the pressure drops to that of the other boilers. When this occurs stop the high pressure feed pump, shut the throttle valve and the discharge valve from the heater and open the feed valve at the boiler from the low pressure feed water main. The operation of such a system is quite simple and far safer than single feed water system.

Cambridge, Mass. R. A. CULTRA.

ANSWERING A. C. in the Aug. 1 issue regarding the necessity of using two feed water systems to supply 11 boilers carrying 120 lb. pressure and one carrying 150 lb. pressure, I would say that I have seen this tried out in two instances. The first was in a plant with four horizontal return tubular boilers, two of which carried 115 lb. and two carried 60 lb. pressure. There was one feed pump and feed line to supply all four boilers. The usual practice was, to feed the low pressure boilers and then close the feed valves and fill the two high pressure boilers at the full capacity of the pump which was a triplex power pump driven by a belt from the mill shafting. Of course this was an unsatisfactory method and made it hard to keep the pressure even. I often tried to regulate the valves to the low pressure boilers so that some water would go into all four at the same time; but it was almost impossible to do this.

The second case was in a plant containing four water-tube boilers carrying 175 lb. pressure and one carrying 135 lb. The four high pressure boilers were equipped with feed water regulators and there was ample pump capacity so no difficulty resulted from the arrangement.

In the case A. C. mentions, much depends on the capacity of his feed pumps. If it is ample, it would be possible to maintain a pressure on the feed main high enough to feed the high pressure boiler at any time. If the low pressure boilers are all equipped with feed water regulators, there will seldom arise a period when all valves are open at the same time; however, there is a possibility that they might all be open at once, in which case, lack of pump capacity would allow the pressure to drop to that of the low pressure boilers.

East Dedham, Mass. G. H. KIMBALL.

Gain in Efficiency by Heating Feed Water

HOW MUCH should our overall plant efficiency be increased by utilizing the exhaust steam and raising the temperature of the feed water from 60 to 210 deg. F.? At present the total heat in a pound of steam evaporated is 1185 B.t.u. V. N.

A. By raising your feed water temperature with exhaust steam from 60 to 210 deg., you save 210 — 60, or 150 B.t.u. per lb. of water evaporated. As the heat in your steam is 1185 B.t.u., the heat added per pound of steam evaporated is

$$1185 - 60 + 32 = 1157 \text{ B.t.u.}$$

The increase, then, in overall plant efficiency is

$$150 \div 1157 = 13 \text{ per cent.}$$

Where no other means are available for heating feed water, it is often considered good practice to heat with live steam, not that any gain in efficiency is obtained but that the strains incident to the feeding of cold water into a hot boiler are relieved. From this it is apparent that the gain of 13 per cent which may be obtained by heating the feed water with exhaust steam is not the only consideration. The financial gain resulting from decreased maintenance costs may be of great importance.

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Power Factor Correction by Means of Static Condensers

Large users of electric power are finding it more and more to their advantage to maintain the power factor of their systems at as high a point as possible. Systems having low power factors have nothing of advantage to offer the consumer, and make it necessary for the power company to provide generating capacity greatly in excess of that required to supply the useful load.

When the field of electric power supply was limited, that is, in the days when the user of electric power was the exception rather than the rule, central stations paid little attention to the matter of power factor, and sold energy to various customers on a more or less uniform basis, regardless of the power factors of the respective loads.

This, obviously, was not fair. It compelled the customer with the high power factor to pay for the excess generating capacity required to supply a large wattless current to customers of low power factor. In other words, the customer with a high power factor paid a higher rate for the electric energy he used than he would have, had the customer of low power factor not been supplied from the same system.

While these considerations are well known to every electrical engineer, it has been difficult to make the idea of power factor, wattless current, etc., clear to the consumer, and as a result, he made little or no effort to raise the power factor of his system.

Today, however, rates are being fixed on a more equitable basis and the central stations are beginning to penalize consumers for low power factor. As a consequence, the consumer is finding it to his advantage to install corrective apparatus.

Power factor correction may be accomplished either by the use of synchronous condensers, or by means of static condensers. Synchronous condensers have a wide field of application and their use as a means of raising power factor is quite common. The static condenser, on the other hand is less known and its use less general although, without exception, it has proven favorable in every case where it has been installed. For the smaller plant, the static condenser, in many cases has the advantage. They are simply installed, they require practically no attention, they are in service 24 hr. a day, have no moving parts, and above all are highly efficient.

In the Sept. 1 issue of this magazine, under the heading of "Remotorizing Plant Raises Power Factor," O. H. Henschel presented an interesting account of the manner in which the power factor of an industrial plant was raised 100 per cent by remotorization. In this issue, Mr. Henschel gives further information in regard to this plant and relates how the power factor was still further increased by the installation of static condensers. Aside from the fact that static condensers were selected as being the most suitable form of corrective device, the article should prove of interest because of the problem involved in their selection. Plant owners and engineers confronted with the problem of raising their power factor will find it to their advantage to read Mr. Henschel's article.

Selection of Piping Equipment in Power Plants

Perhaps the principal difference between one power station and another of like capacity and for similar service, is in the arrangement and selection of its piping. Boilers, generating equipment, and auxiliary equipment have become standardized to a certain extent, and it is in the piping layout that the designing engineer has the greatest opportunity to demonstrate his skill and ability. It is the piping which ties the individual pieces of apparatus together and makes the power plant a unit.

As a factor of importance, therefore, the matter of piping cannot be underestimated; in fact, in many cases, the selection and arrangement of piping determines to a large extent, the efficiency of the plant. Boiler efficiencies, turbine and generator efficiencies and the efficiency of auxiliaries are usually guaranteed by the manufacturer, and if installed in accordance with the manufacturer's specifications, such guaranteed efficiencies can be relied upon. The overall efficiency of the plant, however, is dependent upon the arrangement of the various units which make up the plant, and the manner of connecting them together.

Now, practice in the selection of pipe, fittings and valves, has not become standardized and inspection of various plants will often reveal a wide difference in the kinds of piping equipment used for similar services. Of course, in most cases, the designer or purchaser may exercise considerable leeway in selecting his pipe equipment, but there are certain fundamentals which must be adhered to, if the most satisfactory solution to the problem is desired.

Many questions arise in the layout of a piping job, and unless the engineer responsible has had experience or knows the fundamental points to be kept in mind, he is apt to be confused. For instance, where should steel pipe be specified, what kinds of gaskets should be used on joints for various services, what size bolts should be used for flange connections for certain pressures, where should extra heavy or full weight pipe be specified, what type of joints should be used for steam lines, water lines, air lines, and where should welding be employed, what type of valves should be specified for main steam and water lines, what kinds of pipe and fittings should be used on ammonia lines, what kind of gaskets are used on oil lines, and what kind of insulation should be used for various services? These and a hundred other questions confront the man writing pipe specifications and if the piping job is to be a success he should be able to answer them correctly. To the man who has had considerable experience with piping layouts, these questions present no difficulty, but to those who have done little of this kind of work, it is convenient to have at hand, a ready means of reference for determining correct practice in each case.

In an article appearing in this issue, a table is shown which will give, at a glance, answers to such questions as are listed above. This table will prove of great value to anybody confronted with the task of preparing pipe specifications, and its use will provide a certain degree of uniformity which is to be highly desired.

Heat Balance Is a Big Factor in Plant Design

With the advent of such features as air preheating and economizers, bleeding steam from main units for feed heating, and the use of distilled make-up, the study of station heat balance is a large factor in its influence on station design. Along with this study of heat balance, the general economic considerations must also be carefully analyzed.

Final choice of station equipment, assuming equal reliability, is therefore dependent on two main factors, the first of which is the initial investment and the second, the heat balance which will give the greatest return on the investment. Frequently the investment factor is the more important since it may be desired to keep the capital cost of a station down and take the loss over a period of years due to the lessened efficiency of operation. In some cases, the decision as to choice of equipment will be based on a medium point between these two extremes.

It is only after this aspect of the design problem has been thoroughly studied that the actual layout can be made. From this point on, it will be found that modern station design is gradually being worked out on more or less standardized lines.

In the Barbadoes Island station described in this issue, it is interesting to note that no house turbines have been provided. While both economic and heat balance considerations entered into this decision, the important point is the influence of that decision on the general plant design.

Steam is bled from a single bleed point on the main units to provide a part of the steam required for feed water heating. For make-up the high pressure double-effect evaporator system with high heat level condenser was chosen.

While the evaporator vapor might have been condensed in an open heater, such a system is efficient only in cases where this increase of temperature will not cause a temperature in the heater exceeding the convenience of the heat balance. In this station, if the evaporator vapor were condensed in the open heater it would mean a reduction in the amount of steam bled from the main units. While such an arrangement does not waste any heat, the plant would not be utilizing the opportunity to generate a certain amount of power cheaply, as steam bled from the main unit develops power directly chargeable to the turbine at a heat cost of 4000 B.t.u. per kw.-hr. If an equal amount of power had to be developed by steam expanded to condenser pressure, the heat charged to the turbine would be three or four times as much.

Hence the evaporator vapor is condensed in a condenser in which the boiler feed, used as circulating water, takes up added heat on its way to the boiler.

This is an example of how a study of heat balance, together with constant attention to the cost and the returns from the expenditure, affect the choice of equipment and its layout. Every item of equipment will bear scrutiny with these two factors in mind and of these two it appears that the heat balance in these days of high fuel cost offers the big opportunity in station design.

N. A. S. E. Holds Interesting Sessions at Buffalo

SUCCESSFUL EXHIBIT AND DISCUSSIONS ON COAL STORAGE AND FIRE PREVENTION FEATURE 41ST ANNUAL CONVENTION

FROM the standpoint of exhibitors of power plant equipment, this year's convention of the National Association of Stationary Engineers, held at Buffalo, Sept. 10 to 14, was one of the most successful ever held by that organization. From the viewpoint of the delegates of the various subordinate associations, the convention was equally successful, for the sessions were interesting and instructive not alone because of the association business transacted, but also because of the excellence of the addresses presented by the speakers on the educational program.

Coal storage, the subject discussed by W. L. Abbott, chief operating engineer of the Commonwealth Edison Co., of Chicago, aroused and held the interest of the convention partly because of the timeliness of the subject and partly because of the authoritative source of Mr. Abbott's statements. Mr. Abbott's study of the coal storage situation has been made in connection with his work as chairman of the committee appointed by the Federated Engineering Societies, which undertook the study of this problem, and his statements were therefore accepted without question as to the practicability of the conclusions.

In the opinion of Mr. Abbott, it is both practicable and profitable to store coal and it is his belief that the four arguments against storage, namely interest charges, cost of handling, loss by degradation and loss by fire, are not as insurmountable as they may seem.

He stated that interruptions of supply and difficulties attendant with transportation at certain periods of the year made it necessary to give serious consideration to storage if industry is not to be crippled by lack of coal or exorbitant prices. He asserted that last year consumers probably paid $200,000,000 more for coal than would have been the case if stored coal had been available.

Storage at the mines might be of some benefit, he pointed out, but even such storage would not relieve the situation since transportation and labor difficulties might still affect distribution. It would be necessary, in order to avoid these difficulties, to store at or near the place of consumption.

He thought it might be possible to work out some scheme whereby the cost of storage would be compensated for to some degree. One such arrangement would be seasonal freight rates, since it costs the railroads more per ton mile to handle coal in the winter months than it costs during the summer season. At the same time, this would tend to increase the summer production of coal.

In the cost of coal storage, Mr. Abbott pointed out that the cost of handling was an important item and was one where the employment of machinery could be used to advantage. He said that the investigation showed that the double handling charge varied from 12 to 75c a ton depending on the quantities involved and the general method used. For storage of 25,000 T. and up, present practice seems to be to use car dumpers, some form of mechanical conveyance such as belts and gantry cranes for reclaiming. Where the storage is around 25,000 T., he said that locomotive type cranes have been found useful and for small storages wagon loaders are used.

Since the period of storage is usually about 6 mo., the interest charge is approximately 17 or 18c per ton. He asserted that the handling cost with proper facilities should not be over that same figure.

Mr. Abbott does not believe that disintegration is particularly important, as the loss in storage from this cause is not over 1 per cent at the most. He pointed out, however, that coal in a finely divided state absorbs oxygen and therefore burns more slowly. The heat content has not changed but the coal does not give it up as readily.

It is his belief that proper storage will reduce the fire hazard to the point where it is unimportant. Mineral charcoal or mother of coal absorbs oxygen rapidly and it is this constituent which causes trouble particularly in lignite and the inferior grades of bituminous. This oxidation of coal takes place on exposed surfaces and the finer the coal the greater the danger of spontaneous combustion. Mr. Abbott pointed out that even if the coal which would pass a ⅛-in. mesh were eliminated the danger of spontaneous combustion would be reduced. Even better would be the use of lump coal above 1 in.

Another session which evoked considerable interest was that devoted to the general subject of fire prevention. T. Alfred Fleming, director of conservation of the National Board of Fire Underwriters, talked on fire hazards; Ira G. Hoagland, secretary of the Automatic Sprinkler Association, discussed the automatic control of fires, and George B. Muldaur, general agent of the Underwriters Laboratory, told of the Underwriters' Laboratories service to engineers.

Mr. Fleming pointed out that plant-fire hazards may be materially reduced by proper layout of the building. Vertical and horizontal openings should be protected as this is the cause of about 80 per cent of the fire loss in industry. He also stated that fire doors and walls should be required.

In connection with the special hazards in the building due to boiler and coal rooms, Mr. Fleming asserted that walls of fire resistive construction are a material aid. Oil storage was cited as a particularly critical hazard unless handled in the proper way. Dust was another special hazard mentioned. Every kind of dust except stone dust is explosive, according to Mr. Fleming, and since dust may be exploded by static electricity it is necessary to give careful consideration to this hazard in industrial plants.

Another point made by the speaker was the type of men usually employed for watchmen. He suggested that this job was far too important to give to an aged and decrepit man simply because it offered the only employment for such men.

Mr. Hoagland asserted that so-called fire-proof construction is not sufficient if fire losses are to be reduced. He illustrated his talk with slides showing the effects of fire on buildings of modern construction where the contents were combustible. Automatic sprinklers for the control of fires at their origin plus proper building construction was his suggestion toward reducing loss by fire, which he pointed out has amounted to $1,000,000,000 in the past 2 yr.

Convention Officially Opens on Tuesday

On Tuesday morning, the 41st convention was officially opened by National President Felderman and Chairman Gilroy of the local convention committee. John Howie, representing the Chamber of Commerce, welcomed the delegates to the city of Buffalo. During

the course of his remarks, Mr. Howie, who is also president of the Buffalo Hotel Association, paid tribute to the work of the engineer in adding to the comforts of modern civilization. President Felderman, who responded, called attention to the history of the National Association, pointing out that it had grown from a membership of a few to more than 20,000 in the course of its 40 yr. of development. He emphasized the fact that it is only by meeting with fellow engineers and exchanging ideas that a man can grow in his work. This was followed by a short address by National Vice-President Holbrook, who in turn was followed by past National President Parry. Mr. Parry suggested that the engineer should sell his services by advertising. By way of illustration, he stated that frequently a plant may give perfect service, yet the work of the engineer may not be appreciated by the employer since the employer has been led to expect such service. He maintained that by meeting the employer on his own basis the engineer could materially enhance his position.

After a business session at which President Feldermann appointed various committees, the convention adjourned until the afternoon session. At this meeting, the report of the credentials committee showed that there were 385 delegates and alternates present at the convention.

President Felderman, in his report presented at this time, called particular attention to the educational purposes of the association.

Reports were also received from National Deputy Holbrook on the general condition of the local associations. He suggested that improvements might be made in the method of record keeping so that the national organization would have more accurate records. Various other reports were also received at this session.

On Tuesday evening the session was under the direction of Chairman Fagnan of the Technical Papers Committee, and it was at this meeting that the discussion on fire prevention previously referred to, took place.

Association business made up the work of Wednesday morning at which time the following reports were received: Membership Extension Committee, J. A. Wickert, chairman; Technical Papers Committee, D. L. Fagnan, chairman.

No official session was held on Wednesday afternoon and the delegates visited various points of interest in and around Buffalo. On Wednesday evening the California Association entertained the delegates at a reception.

Official business was continued on Thursday although a part of the morning was taken up by the address of Mr. Abbott on the subject of coal storage. One report of particular interest was that of the License Committee. The report of this committee was prepared in printed form for distribution to the delegates.

Attempts to pass license laws in several states has not been successful. In the opinion of the committee, this result is in a measure the fault of the engineers, themselves, largely through the lack of co-operation.

In the evening, the exhibitors' entertainment, which is always a feature of the convention, drew the attention of the delegates and their friends. At this entertainment, the following program was given:

Daddy Green's World's Famous Tumblers—courtesy Home Rubber Co.

G. T. Ogden, song and story — courtesy C. E. Squires Co.

Bill Jones—courtesy Tidewater Oil Sales Corp.

The Dickerman Twins—courtesy Johns-Pratt Co.

Professor No-Ox-Id, magician—courtesy Dearborn Chemical Co.

Bob Jones—courtesy Garratt Callahan Co.

Jack Armour — courtesy McGraw-Hill Co., New York City.

Joe McKenna—courtesy Jenkins Bros.

Toby Fitzpatrick, accompanist.

Program arranged by Paul T. Payne, chairman.

Friday was a big day for the convention on account of the election of officers and the choice of next year's convention city. This year the officers were selected practically without contest and the choice of Grand

Rapids, Mich., as the next convention city was made by an overwhelming vote. New officers are as follows: Royal H. Holbrook, Iowa, president; Dudley G. Kimball, Massachusetts, vice-president; Fred W. Raven, Illinois, secretary; Samuel B. Force, treasurer; Joseph F. Carney, New York, trustee; James Heath, New Jersey, national conductor; Mr. Marquis, Tennessee, doorkeeper.

Officers for the National Exhibitors' Association were elected as follows: president, A. W. France of the France Packing Co.; vice-president, W. P. Lyons of the Johns-Manville Co.; treasurer, G. R. Rowland of the Texas Co. Executive committee: Charles F. Green of the Home Rubber Co., chairman; W. L. Schaffer of the National Tube Co.; Jacob Eige of the Fisher Governor Co.; F. D. Tuthill of the McLeod & Henry Co.; William L. Goddard of the Crane Co. The officers and executive committee reappointed F. N. Chapman of the A. Leschen & Sons' Rope Co., St. Louis, Mo., as secretary for the third consecutive year.

List of Exhibitors

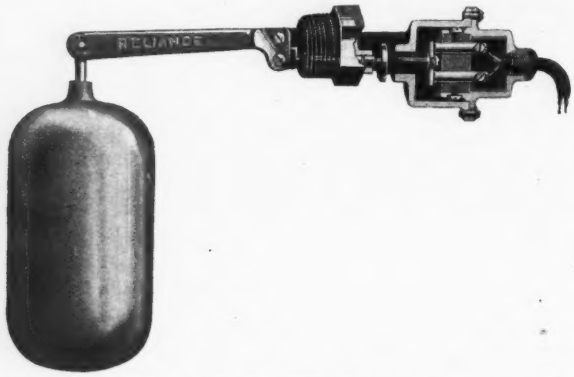
Alberger Heater Co., Buffalo, N. Y.
Allis-Chalmers Mfg. Co., Milwaukee, Wis.
American Radiator Co., Buffalo, N. Y.
V. D. Anderson Co., Cleveland, O.
Armstrong Machine Works, Three Rivers, Mich.
Art Metal Construction Co., Jamestown, N. Y.
Ashton Valve Co., Boston, Mass.
Baldwin Chain & Mfg. Co., Buffalo, N. Y.
Belmont Packing & Rubber Co., Chicago, Ill.
Bernitz Furnace Appliance Co., Boston, Mass.
Birch Manufacturing Co., Chicago, Ill.
Boig & Hill, Inc., New York, N. Y.
Boiler-Kote Co., Chicago, Ill.
Brooks Oil Co., Cleveland, O.
Buffalo Mill Supply Co., Buffalo, N. Y.
Edwin Burhorn Co., New York, N. Y.
F. N. Burt Co., Buffalo, N. Y.
Bussman Mfg. Co., St. Louis, Mo.
Calebaugh Self-Lubricating Carbon Co., Philadelphia, Pa.
Jas. Clark Electric Co., Buffalo, N. Y.
Coen Co., Inc., New York, N. Y.
Cokal Stoker Corp., Chicago, Ill.
Crandall Packing Co., Palmyra, N. Y.
Crane Co., Chicago, Ill.
Crane Packing Co., Chicago, Ill.
Chapman Valve Mfg. Co., Indian Orchard, Mass.
Chicago Down Draft Furnace Co., Chicago, Ill.
Chicago Faucet Co., Chicago, Ill.
Chicago Metallic Packing Co., Chicago, Ill.
Cyclone Grate Bar Co., Buffalo, N. Y.
John W. Danforth Co., Buffalo, N. Y.
Dearborn Chemical Co., Chicago, Ill.
M. H. Detrick Co., Chicago, Ill.
Diamond Power Specialty Corp., Detroit, Mich.
Joseph Dixon Crucible Co., Jersey City, N. J.
Economy Fuse & Mfg. Co., Buffalo, N. Y.
Elk Fire Brick Co., Buffalo, N. Y.
Elliott Co., Pittsburgh, Pa.
Erie City Iron Works, Erie, Pa.
Everlasting Valve Co., Jersey City, N. J.
Farrar & Trefts, Inc., Buffalo, N. Y.
Faul & Timmins Co., Buffalo, N. Y.
Fisher Governor Co., Marshalltown, Ia.
Flexible Steel Lacing Co., Chicago, Ill.
J. B. Ford Co., Wyandotte, Mich.
France Packing Co., Philadelphia, Pa.
Garlock Packing Co., Palmyra, N. Y.
Garrett Callahan Co., Chicago, Ill.
General Specialty Co., Buffalo, N. Y.
Grapho Metal Packing Co., Indianapolis, Ind.
Graver Corporation, E. Chicago, Ind.
Greene, Tweed & Co., New York, N. Y.
Hackman Manufacturing Co., Milwaukee, Wis.
Hawk-Eye Compound Co., Blue Island, Ill.
Hill Pump Valve Co., Chicago, Ill.
Hollow Center Pkg. Co., Cleveland, O.
Home Rubber Co., Trenton, N. J.
Homestead Valve Mfg. Co., Homestead, Pa.
Howard Bros. Boiler Works, Buffalo, N. Y.
Howard Iron Works, Buffalo, N. Y.
Paul B. Huyette Co., Philadelphia, Pa.
Industrial Management, New York City, N. Y.
Industrial Power, Chicago, Ill.
Jefferson Union Co., Lexington, Mass.
Jenkins Bros., New York, N. Y.
Johns-Manville, Inc., New York, N. Y.
Johns-Pratt Co., Hartford, Conn.
Jointless Fire Brick Co., Chicago, Ill.
Keasbey & Mattison Co., Buffalo, N. Y.
Keystone Association, No. 16, Buffalo, N. Y.
Keystone Lubricating Co., Philadelphia, Pa.
King Refractories Co., Buffalo, N. Y.
Lagonda Mfg. Co., Pittsburgh, Pa.
Lake Erie Manufacturing Co., Buffalo, N. Y.
A. Leschen & Sons Rope Co., St. Louis, Mo.
Libbey Glass Mfg. Co., Toledo, O.
Liberty Mfg. Co., Pittsburgh, Pa.
Liptak Fire Brick Arch Co., Chicago, Ill.
London Steam Turbine Co., Troy, N. Y.
Lunkenheimer Co., The, Cincinnati, O.
Manning, Maxwell & Moore, Inc., New York, N. Y.
Mason Regulator Co., Boston, Mass.
Mattingly Automatic Valve Co., St. Louis, Mo.
McCarthy Bros. & Ford Co., Buffalo, N. Y.
McLeod & Henry Co., Troy, N. Y.
Metric Packing Co., Buffalo, N. Y.
Mollenberg-Betz Machine Co., Buffalo, N. Y.
Monash-Younker Co., Chicago, Ill.
National Engineer, Chicago, Ill.
National Tube Co., Pittsburgh, Pa.
Niagara Asbestos Corp., Buffalo, N. Y.
Niagara Welding & Boiler Works, Inc., Niagara Falls, N. Y.
Northern Equipment Co., Erie, Pa.
Oldman-Magee Boiler Works, Inc., Buffalo, N. Y.
Otis Elevator Co., New York, N. Y.
Palmyra Packing Co., Palmyra, N. Y.
Permutit Co., New York, N. Y.
Perolin Co. of America, Chicago, Ill.
Philadelphia Grease Mfg. Co., Philadelphia, Pa.
Pioneer Rubber Mills, New York, N. Y.
Wm. Powell Co., Cincinnati, O.
Power, New York, N. Y.
Power Plant Engineering, Chicago, Ill.
Quaker City Rubber Co., Philadelphia, Pa.
Quigley Furnace Spec. Co.,
Refractory Products Co., Cleveland, O.
Reliance Gauge Column Co., Cleveland, O.
Richardson-Phenix Div., Fort Wayne, Ind.
Richardson Scale Co., Passaic, N. J.
Sanford Riley Stoker Co., Worcester, Mass.
Robertson-Cataract Elec. Co., Buffalo, N. Y.
Robertson Co., John F., Pittsburgh, Pa.
Roeblings' Sons Co., J. A., Trenton, N. J.
Root, Neal & Co., Buffalo, N. Y.
Ross Heater & Mfg. Co., Inc., Buffalo, N. Y.
Roto Co., Hartford, Conn.
J. H. Ruckel & Son, Buffalo, N. Y.
Sherwood Mfg. Co., Buffalo, N. Y.
Skinner Engine Co., Erie, Pa.
Smith Publishing Co., W. R. C., Atlanta, Ga.
Squires, C. E. Co., Cleveland, O.
Standard Oil Co. of N. Y., Buffalo, N. Y.
Stebbins, C. M. Oil Co., Buffalo, N. Y.
Sugar Beet Products Co., Saginaw, Mich.
Sun Oil Co., Buffalo, N. Y.
Taber Pump Co., Buffalo, N. Y.
Texas Co., New York, N. Y.
Tidewater Oil Sales Corp., New York, N. Y.
Trill Indicator Co., Corry, Pa.
Union Steam Pump Co., Battle Creek, Mich.
U. S. Rubber Co., New York, N. Y.
Vacuum Oil Co., New York, N. Y.
Vulcan Soot Cleaner Co., Du Bois, Pa.
Wagner Mfg. Co., Cedar Falls, Ia.
Walbridge & Co., Buffalo, N. Y.
Walworth Mfg. Co., Boston, Mass.
Westinghouse Elec. & Mfg. Co., East Pittsburgh, Pa.
Wickes Boiler Co., Saginaw, Mich.
D. T. Williams Valve Co., Cincinnati, O.
"X" Laboratories, New York, N. Y.
York Manufacturing Co., York, Pa.

As previously mentioned, this year's exhibit was considered by both exhibitors and delegates as one of the most successful ever held. A wide diversity of apparatus was shown and the arrangement of booths was such as to show the equipment to the best advantage.

Low Water Is Indicated by Electric Signal

SINCE a whistle alarm cannot be depended upon for boilers where the pressure drops below 2 lb., the Reliance Gauge Column Co., of Cleveland, Ohio, has recently developed an electric alarm which affords protection for low-pressure boilers.

Operation of this device depends upon a float which presses up and holds the electric switch open as long as



WHEN THE FLOAT LOWERS, THE ELECTRICAL CIRCUIT TO LAMPS OR A BUZZER IS CLOSED

the water is above a certain point. When the water level falls, the float lowers the lever, closing the circuit and operating the alarm signal until the water level rises again out of danger. This signal may be a light, bell or buzzer, as desired, at any distance from the boiler.

Two Developments Under Way in Tennessee

TWO plants now being constructed by the Tennessee Electric Power Co. will add 35,000 kw. to the generating capacity of its system. One of these plants is a steam generating station located on the Tennessee River at the Hales Bar hydroelectric station. This will be one of the most modern steam plants in the South, the initial installation to comprise a single 20,000-kw. turbine unit with a surface condenser having 35,000 sq. ft. cooling surface. The turbine will have 14 stages and will weigh approximately 300 T.

Steam will be furnished this unit by three 1035-hp. water tube boilers each of which will have a heating surface of 11,000 sq. ft. Two boilers operating at 300 per cent of rating will supply sufficient steam to operate the turbine, leaving one boiler as spare. These boilers will generate steam at 400 lb. pressure which will be superheated 280 deg. with a final temperature of 725 deg. The steam header will go directly to the turbines with no outlets for auxiliaries as the only steam driven auxiliary will be the dry vacuum pump which will be of the steam jet type.

There will be a closed air-cooling system for the generator and the air will have the heat extracted by passing over radiators in which will flow condensed steam. The feed water will be brought to 212 deg. by steam taken from the seventh and eighth stages of the turbine through a two-stage heater.

Another point of interest is that the economizer will be set on the floor level and there will be no breeching required, as the economizer induced draft fans and air preheaters will form the connection from the boilers to the stack. The air preheaters will raise the air temperature approximately 70 deg. before entering the forced draft fans. The layout of the entire plant is such that more units can be added up to an ultimate capacity of 100,000 kw.

Additions to the Great Falls hydroelectric plant, located on the Caney Fork River at Rock Island on the Cumberland Plateau, comprise the other plant. The present plant consists of a 40-ft. concrete dam and a 10,000-kw. single vertical water wheel unit operating under a 110-ft. head. The Collins River joins the Caney Fork River just above the dam and makes a wide bend which carries it very close to the Caney Fork River about 1 mi. downstream from the dam. The 110-ft. head on plant is obtained by a 500-ft. tunnel at the point where the two rivers come close together. Work is now in progress to increase the height of the dam 35 ft., drive a second tunnel, and add a second unit of 15,000 hp. capacity. The higher dam will increase the storage from 9000 acre feet to 41,000 acre feet.

Muscle Shoals Power Plant Conference of Sept. 6

NEGOTIATIONS leading to a transfer of interests in the Muscle Shoals power plant at Sheffield, Ala., may culminate from the visit of Henry Ford to Washington and conference with Secretary of War Weeks, and President Coolidge on Sept. 6. The Ford Motor Co.'s offer of $5,000,000, which extends to Nov. 1, is hindered, it develops, by a claim on the Gorgas power unit of the Muscle Shoals plant by the Alabama Power Co., for its purchase at $1,000,000. From statements regarding the conference, it is indicated that the Ford interests are desirous of acquiring this plant and the Government may take some action toward a separate settlement of the Alabama Power Co.'s claim, though it is possible that a transfer independent of this unit may result.

Coal Commission Opposes Nationalization of Mines

IN THE REPORT of the United States Coal Commission, which was submitted to the President, Sept 13, suggestions and recommendations are given which may lead to improved relations between the operators and miners and considerably lessen the probability of national coal strikes.

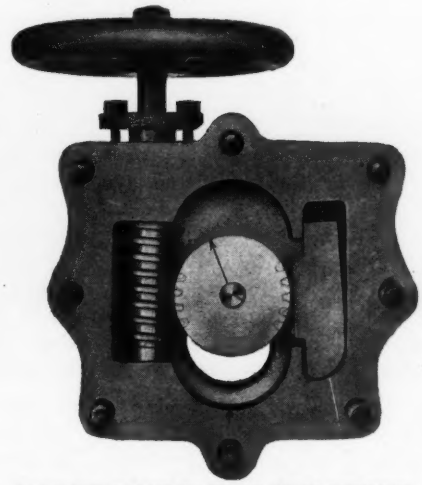
In brief, the report opposes nationalization of the mines, the compulsory arbitration of disputes between workers and operators and recommends compulsory investigation, under authority of the president, where a strike threatens, so that the facts will be given publicity

and bring to bear the power of public opinion in compelling settlement without suspension of work.

Following this report, it is said the president has asked the Federal Trade Commission, which is authorized by law to report unfair trade practices, to investigate any cases of alleged profiteering in anthracite coal which may arise. The data collected by the United States Coal Commission are available for these investigations.

Worm Actuates Geared Valve Disc in New Blowoff Valve

USE IS made of a worm for actuating the valve disc in a new type of blowoff valve which has recently been developed by the Perolin Co. of America, Chicago, Ill. This valve is made up of a central ring which carries a hand wheel, stem and stuffing-box; the worm, a



BLOWOFF VALVE IN HALF OPEN POSITION

solid disc with gear teeth cut between its faces and a movable rack. On each side of this central ring are bolted the covers with ground seats and pipe connections which make up the completed valve.

As the hand wheel is turned, the worm rotates the geared disc, and because of its contact with a rack on the opposite side from the worm, the disc moves up with a rotating, sliding motion. When the disc reaches the top of its travel, the rack, which is held by springs, is pressed back by the tooth pressure and permits the disc to rotate without any harm being done. The same protection is afforded when the valve is closed.

With this type of valve there is no special inlet or outlet side; in fact, if the seat on the pressure side finally wears out the valve may be turned end for end. For this reason, it has been given the trade name of "Double Service." On account of the rotating, sliding motion of the disc during opening and closing, the valve is said to regrind automatically and adjust the disc to the seat.

HIGH PER CENT of CO will cause secondary combustion if air reaches the hot gases through leaks in the boiler setting, flues or stack. This ignition causes excessive temperatures, which result in overheating the flues or stack.

News Notes

C. M. DECKER, Philadelphia representative of the Geo. T. Ladd Co., has moved his office from the Land Title Bldg. to 504 Franklin Bank Bldg., Philadelphia.

JOHN W. DOUGHERTY, chief engineer of the Bangor (Maine) Water Works, died Sept. 8 of acute indigestion, aged 53. He leaves a wife and daughter.

SARCO CO., INC., of New York City, has just appointed R. C. Doerr, formerly sales representative of the National Meter Co., as its engineering sales representative for northern New Jersey.

S. C. SPERRY CO., of Cambridge, Mass., has been awarded the contract for the construction of the new power plant at Amsterdam, N. Y., for the Mohawk Carpet Mills of that town. F. P. Sheldon & Sons, of Providence, R. I., are the engineers.

FORD MOTOR CO. has ordered from the Westinghouse Electric & Manufacturing Co. four 4500-kv.a., 13,200-v., three-phase, 60-cycle, 72-pole, 100-r.p.m. vertical waterwheel generators with thrust bearings and direct-connected exciters. The order was placed through the Stone & Webster Co., Inc., contractors. The generators will be installed in the hydroelectric station of the Twin City plant of the Ford Motor Co. at St. Paul, Minn. Much of the power from this station will be used for industrial purposes in the Ford plant and the rest will be sold.

HOMESTEAD VALVE MFG. CO., manufacturer of the Homestead quarterturn valve, announces that a consolidation has been effected with the Protected Seat Valve Co. of the Peoples Bank Bldg., Pittsburgh, Pa. The Protected Seat Valve Co. has been manufacturing the B. & O. Protected seat globe valve and the Protected seat hydraulic operating valve, also a line of check valves and angle valves with the protected seat feature. This line will now be made at the plant of the Homestead Valve Mfg. Co., and marketed along with the other products of the Homestead Co.

GRAVER CORPORATION at East Chicago, Ind., announce the following changes in their district offices: The office at Los Angeles has been discontinued and the Water Works Supply Co., 536 Call Bldg., San Francisco, will represent the company in the entire state of California. The Seattle office has been discontinued and states of Washington and Oregon will be in charge of H. K. Mead, 409 Board of Trade Bldg., Portland, Ore. The Philadelphia office has been discontinued and L. C. Holmes, 918 Buchanan St., N. W., Washington, D. C., will have charge of sales in this district.

LANGDON GIBSON, noted explorer and brother of Charles Dana Gibson, well-known contemporary artist, died Sept. 5 at Criehaven, Maine, where he was spending the summer. Death was due to cerebral hemorrhage. He was a native of Boston and was 58 yr. old. Mr. Gibson, up to 2 yr. ago, was production manager of the General Electric Co., Schenectady Works. He had been associated with that concern for 31 yr. and was well-known throughout the industrial world. He was a man of great activity and vigor, being one of the few members of the Stanton expedition successfully completing the expedition through the Grand Canyon of the Colo-

rado River in 1889. He gained added fame through his accompanying Admiral Peary's second northern expedition to explore and map the northern coast of Greenland.

UNITED STATES Civil Service Commission announces examinations for Associate Mechanical Engineer, $2500 to $3600 a year and Assistant Optical Engineer, $2000 to $3000 a year. Receipt of applications will close Oct. 23. The examinations are to fill vacancies in the Ordnance Department at Large, Frankford Arsenal, Philadelphia, Pa., at the entrance salaries named above, and vacancies in positions requiring similar qualifications. The duties of associate mechanical engineer consist of the design and supervision of the manufacture of precision instruments which will generally include optical elements; the duties of the assistant optical engineer consist of the study of optical materials and the design of the optical systems for the above instruments. Competitors will not be required to report for examination, but will be rated on their education, training, experience, and fitness. Full information and application blanks may be obtained from the United States Civil Service Commission, Washington, D. C., or the secretary of the board of U. S. civil-service examiners at the post office or customhouse in any city.

Books and Catalogs

THE AMERICAN SOCIETY OF HEATING AND VENTILATING ENGINEERS GUIDE; 408 pages, size 6 by 9 in. Cloth, New York, 1923.

This, the second annual edition of the Guide, incorporates several changes in arrangement and style in addition to much new and revised material. The volume includes the latest available data on steam, hot water, and warm air heating; heat losses from buildings; piping systems; automatic temperature control; insulation; air conditioning; refrigeration; exhaust and collecting systems; ventilating systems; and subjects of similar character for all classes of work—homes, factories, offices, public buildings, etc.

The book is divided into two distinct sections; one on heating and the other on ventilation. The material in each section is presented in a logical order and any desired information can be readily located. In this respect, this volume is a distinct improvement on the previous one. The text matter is quite comprehensive and should enable one to solve any problem that comes up in daily heating and ventilating engineering practice.

THE CoKAL Stoker Corporation, 341 E. Ohio St., Chicago, Ill., has just issued an attractive 32-page booklet describing its stoker. The action of this stoker is fully explained and illustrated by means of many excellent sectional views and diagrams. In the latter portion of the booklet are shown line diagrams of typical boiler settings using the CoKal stoker.

RELIANCE ADJUSTABLE SPEED Direct Current Motors are discussed in bulletin No. 1014 now being distributed by the Reliance Electric & Engineering Co., of Cleveland, Ohio. Adjustable speed is obtained by gradually shifting the motor armature endwise along its axis away from its normal position directly under the main field poles, resulting in a gradual, smooth, continuous change in speed. In changing of speed, the electrical circuits of the motor are not disturbed as the operation is entirely mechanical. It is stated that speed ratios as great as 10 to 1 are easily effected by this method. Besides describing the general principles of operation, the bulletin also goes into the details of the construction for this line of motors.

THE SARCO Co., INC., of New York City, has issued a new folder giving information on sizes and types of traps to be used with laundry machinery and methods of piping are also recommended.

MANZEL FORCED FEED OIL PUMPS for cylinder lubrication are described in a new folder issued by the Manzel Bros. Co., of Buffalo, N. Y. These oil pumps operate on the piston valve principle and the advantages of this type and design are presented.

DOUBLE-SERVICE BLOWOFF VALVES is the title of a folder now being distributed by the Perolin Co. of America, Chicago, Ill. In this valve, the disc is geared to a worm and when the worm is rotated by a hand wheel, the disc is rotated off the seat with a sliding motion.

WATER FILTERS of the horizontal pressure type are covered in bulletin No. 501 recently published by the Graver Corp., of East Chicago, Ind. Tabulations of capacities, dimensions and weight are given in order to aid the designers of plants in the layout of new equipment.

JENKINS RAPID ACTION VALVE is described in a folder recently issued by Jenkins Bros., of New York City. This type of valve is lever operated and is suitable for such applications as soot blowers and for any other purposes where it is desired to reduce the time element required for opening and closing valves.

ALLIS-CHALMERS Manufacturing Co., of Milwaukee, Wis., has just issued Bulletin 1118-B covering type "AR" squirrel-cage induction motors. These machines are made in sizes from ½ to 200 hp. and while, in general, they cover the same ratings as the former type "AN" motors, they represent a new development throughout.

WESTINGHOUSE ELECTRIC & MANUFACTURING Co. has issued a new catalog covering line material and porcelain insulators. The catalog is suplementary to the company's large supply catalog and has been issued for the convenience of purchasers of these two allied lines of materials. It is a 200-page publication of convenient size.

How HYTEMPITE is used with crushed fire brick for furnace walls and baffles and repairs is discussed in a booklet which is now being distributed by the Quigley Furnace Specialties Co., of New York. Instructions are given for preparing the mixture and considerable information is also presented on just how the work of installing a baffle or furnace lining should be carried out.

"LOPULCO PULVERIZED FUEL SYSTEMS" is the title of a new catalog offered by the Combustion Engineering Corporation, of New York City. This publication describes both the theory and mechanical features of their powdered coal system. It contains illustrations, including a section through a Lopulco equipped boiler plant which shows all the different elements of the system, as well as test data, and information concerning some of their outstanding installations.